

Intensive multiple-use forest management in the tropics

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Analysis of case studies from
India, Africa, Latin America and
the Caribbean

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ABSTRACT

Case studies on intensive multiple-use forest management were conducted in Kerala (India), Ghana, Honduras and Trinidad and Tobago. Each study describes the forest and the ecological, socio-economic, political and administrative factors influencing forest management in the area and the forest management systems themselves including multiple-use of the resource. The systems are evaluated in relation to stated socio-economic objectives and the possibilities and constraints for further development are discussed. Part I of this paper is a synthesis of the findings derived from these studies and in Part II, each study is presented in a summarized form.

FOREWORD

Increasing awareness of the multivarious functions of tropical forests has highlighted the need to develop appropriate systems for their management. Failure to do so will lead to rapid deforestation and eventual disappearance of these valuable forests. The burgeoning demands and the often high density of population make it necessary to develop intensive multiple-use management systems. This, however, requires a good knowledge of existing practices and their deficiencies in fulfilling different objectives. To gather the necessary background, the Forestry Department of FAO initiated case studies in representative countries in India, Africa and Latin America. The present publication synthesizes the findings from studies in Kerala (India), Ghana, Honduras and Trinidad and Tobago.

Forest management in Kerala has a long history and attempts have been made to systematically manage the forests during the last few decades. The region is a typical less developed one characterized by high population density and forest management has to face complex socio-economic problems.

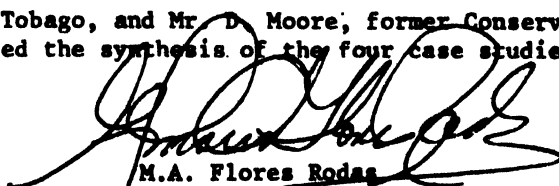
In Ghana, the management of the forests started at the beginning of this century and the study describes the management both of the tropical mixed forests in the middle and southern part as well as the forests in the northern drier savanna zone. The socio-economic conditions are quite different from those of Kerala and the population density is less than one tenth of that country.

Trinidad and Tobago has a very long tradition in forestry and the management of the tropical mixed forests has resulted in some of the highest average commercial yields achieved in this type of forests. Because of the limited resources available on the densely populated islands, forest management has been very intensive and intermediate agricultural cropping has until recently been an important part of plantation establishment techniques.

The case from Honduras is in many ways quite different from the others. The study deals with management of natural tropical pine forests and intensive forest management was only introduced in this country some 10 years ago. The reorganization of public administration of forest resources gave the Honduran Forest Development Corporation exclusive right to manage the forests and a specific mandate to include the rural population in forest development activities. This approach to resource management is to a certain extent unique and has influenced forestry in the Latin American region profoundly.

From the above, it would appear that the four case studies represent very different conditions although the objectives of forest management are quite similar in all cases. It is therefore hoped that the reader may be able to learn from the parts of this study that have relevance on his own situation.

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GLOSSARY

| | |
|------------------------------------|--|
| Annual coupe | the area of forest cut annually in a felling series |
| COHDEFOR | Honduran Forest Development Corporacion Corporación Hondureña de Desarrollo Forestal |
| Compartment | a territorial unit of a forest permanently defined for purposes of administration, description and record. It is the smallest permanent sub-division of a forest |
| dbh | diameter at breast height |
| Division | forest district; term used in Commonwealth countries |
| Exploitable girth | the size of circumference above which exploitation is permitted according to the management plan |
| Felling (or cutting) cycle | the period in which all portions of a felling series are worked under a definite type of felling in a planned sequence. The term polycyclic is sometimes applied to uneven-aged forests as opposed to mono-cyclic. The term should not be confused with "rotation" |
| Felling series | an area of forest delimited for management purposes and forming the whole or part of a working circle |
| Growing stock | all the trees growing in a forest or in a specified part of it, generally expressed in terms of number or volume |
| Hoppus foot and | a unit of volume for round timber based on the substitution of $(\frac{\text{girth}}{4})^2$ for the true cross-sectional area $\frac{g^2}{4 \times \pi}$ used in true volume |
| Hoppus basal area | also a unit of basal area in management and research |
| Rotation | the planned number of years that elapses between the formation and felling of a stand |
| Royalty | payment made to the owner or lessor of a forest for the right of exploiting it, generally based on a rate per unit of produce removed |
| Stumpage | the value of timber as it stands uncut in terms of an amount per cubic unit |
| Time of passage | the time taken for trees to grow out of one size class and into the next |
| Tropical shelter-wood System (TSS) | general opening of the canopy by climber cutting and progressive reduction of the middle tree storey by cutting, girdling and/or poisoning the undesirable trees |

| | |
|----------------|---|
| Uniform System | a shelterwood system in which the canopy is opened fairly evenly throughout the regeneration area; regeneration is mainly natural, though it may be supplemented artificially; regeneration interval fairly short and resultant crop more or less even-aged and regular |
| Working circle | an area (forming the whole or part of the working plan area) organized with a particular object and under one silvicultural system and one set of working plan prescriptions. In certain circumstances, working circles may overlap |

Currencies (1.10.1984; rates may have been different at the actual time of writing)

| | |
|----------------------------|----------------------|
| Lempira (Honduras) | 1 US\$ = 2.00 Lps |
| Rupee (Kerala) | 1 US\$ = 11.85 Rs |
| Cedis (Ghana) | 1 US\$ = 38.50 Cs |
| T&T \$ (Trinidad & Tobago) | 1 US\$ = 2.40 T&T \$ |

PART I

**A Synthesis of Case Studies in Intensive
Forest Management (including Multiple-Use)
in Kerala, Ghana, Trinidad and Tobago
and Honduras**

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SUMMARY

Case studies were made of the management of tropical forests in respect of the State of Kerala in India, Ghana, Trinidad and Tobago and Honduras. This publication seeks to evaluate the results of management, including multiple-use of the forest, and to draw conclusions which may be helpful to others. All four countries lie within the tropics and population densities vary from 34/km² (Honduras) to 668/km² (Kerala). Until oil was discovered in Trinidad all had economies based on agriculture and/or forestry.

In Ghana, Kerala and Trinidad forest reservation began between 60 and 100 years ago and in these countries the reserves now comprise between 20% and 28% of the total land area. In Honduras forest reservation has commenced only relatively recently. In addition to a legally constituted forest estate, two other pre-requisites are of importance to the rational development and management of the forest estate. The first of these is a statement of Forest Policy to provide broad guidance concerning the direction in which Government expects management to proceed and the second is a legal framework within which management can operate. In the case of Ghana, Kerala and Trinidad, the policies are broadly similar in that they relate to the reservation of an adequate forest estate, the protection of catchment areas, the provision of shelter for other forms of land use, the provision of a sustained supply of wood and other forest products, the encouragement of forestry on private lands, the training of staff and the conduct of research into tropical forestry and forest products. As one might expect from three countries earlier influenced by the same colonial power, the legal framework in each is roughly similar and provides a Forest Act which deals with the constitution of forest reserves, duties and responsibilities of officials, defines forest offences and lays down penalties for infringement of the law and sets out procedures for bringing offenders to court, etc. Rules can be made under the Act to regulate transport of produce, etc. Other Acts relating to the forests include Wildlife Protection, Cattle Trespass, Timber Concessions Act, etc.

In Honduras, laws and policies related to rural development are influenced by the long tradition of rural organization. The same applies to forestry. Important objectives of the Forestry Law (Decree No. 85 of 10/2/72), and particularly of the law establishing the "Corporación Hondureña de Desarrollo Forestal" (COHDEFOR) (Law-Decree No. 103 of 15/1/74), are the sustained management of the national forest resources with an active participation of the rural people.

"Social Forestry" was one of the main objectives in the creation of COHDEFOR, and this law was not only a historical milestone in the country's forest development, but it also had a great impact on the entire forestry sector of the Region. The aim was to seek increasing benefits from forestry for the local population by introducing agro-forestry and organize rural people in associations that could participate not only in the traditional resin-tapping activities but also in forest management and protection.

Unfortunately, the inadequate regulations in this law, administrative problems within COHDEFOR, and political and economic constraints at the national level, have impeded the proper implementation of the above-mentioned objectives.^{1/}

^{1/} Some of those impediments have been removed after the writing of the case study from Honduras in 1981; see pages 9 and 10.

The Las Lajas Forest Management Unit (LLFMU) was placed under a management plan in 1976 and has served as a model for all other areas. The area which covers 77 598 ha is divided, for administrative purposes, into five sub-divisions and the total area of pine forests in the LLFMU extends to 39 059 ha. Of these 48% are privately owned and are composed principally of Pinus oocarpa (62.7%) with the remainder being P. caribaea and P. pseudostrobus. The total volume was estimated to be 2.213 million m³ and 92% of the area had more than 25 m³/ha. The population of the LLFMU amounts to 9 360 persons, some 56% of the energy required for lighting and cooking comes from the forest. Most of the agricultural land is held by farmers owning less than 3 ha each and some 32% of them have no legal title to the land they occupy.

The stated objects of management in the LLFMU include the sustained yield from the forest in perpetuity, rationalized harvesting of mature and over-mature areas and the regulation of fire-wood and domestic timber supplies, the control of grazing and the conservation of soil and water in critical areas. Full consideration was given to the social forestry aspects of the Law and efforts to identify the means of attaining such objectives are prescribed in the plan. The silvicultural system is to clear-cut leaving seedtrees and natural regeneration is complemented with planting in areas under intensive management.

The emphasis which the Government places on 'social forestry' is quite clear but there are many difficulties. The management plan for LLFMU therefore follows the traditional form and concept for such a plan but gives prominence to the desirability of incorporating as far as possible the activities of the local population. The LLFMU plan still has, however, to find the means of incorporating social forestry and implementing multiple-use as an integral and workable part of the plan.^{1/}

Certain constraints to development have emerged. Legislation requires the Honduran Corporation for Forest Development (COHDEFOR) to institute agro-silviculture programmes jointly with the National Agrarian Institute (INA) but the necessary soil surveys are still a distant possibility, low stumpage fees are subsidizing the sawmilling industry and international funding will only be granted for investment in Government-owned forest areas. The application of multiple-use is complicated by the pressure by local population for land, and the lack in many cases of legal ownership of the land.

The case studies reveal that certain actual or potential uses of the forest are mutually compatible while others are completely incompatible. Primarily, compatibility or otherwise depends upon the intensity with which any one use is pursued. In the case of watershed protection the protective function diminished as forest cover is exploited, particularly for wood, and the changes in pattern of land use are generally dictated by socio-economic and commercial pressures and not as a result of land capability assessments. Kerala, Ghana and Trinidad all demonstrate practices leading to the view that management condones or initiates practices which lead to mining of the forest for timber at the expense of sustained yield and to the detriment of other forest benefits.

The concept of multiple-use as practiced in the past depended upon a low man/land ratio but as populations increased and access improved, priority products emerged and management intensified in a particular direction to satisfy the demand. In all areas the trend is strongly from protection forest to forest worked under a selection system to

^{1/} A special project on social forestry was initiated in 1983 in several management units in the country

conversion to plantations with multiple-use diminished progressively at each stage.

For the future two alternative trends of development seem possible. These are:

1. Agricultural productivity will remain static and increased production will come from increasing the areas under agriculture at the expense of the forest areas, perennial crops will be expanded for export markets, grain imports will increase, unemployed persons will encroach on existing forests, industrial expansion will continue with increasing demands on the forest for raw material and Governments will accelerate timber production to increase revenue or
2. The area of agricultural land will be stabilized and increased production will come from increased productivity, the trend towards perennial cash crops will be reversed, manufacturing capacity will expand in sectors not dependent upon agro-forestry raw materials, Government reliance on forest revenue will be reduced by improvements in the agricultural and industrial sectors and priority will be given to diversifying the products supplied by the forest to local populations.

In conclusion, it appears that multiple-use management will, at some stage, have to be introduced in each of the study areas and the following will have to be given priority;

1. The formulation of a policy for integrated land use for agriculture, forestry, energy, industry and related sectors.
2. The allocation of land to specific uses on the basis of land capability.
3. The zoning of land for uses which are mutually exclusive.
4. The formulation of appropriate systems of multiple-use.

INTRODUCTION

1. Case studies of intensive multiple-use tropical forest management were carried out in 1983 in respect of Ghana, Honduras, the State of Kerala (India) and Trinidad and Tobago. Part I of this publication seeks to analyse and compare the results of these case studies, to evaluate the results of management in relation to the physical, economic and social environment within which management operates in each case and to draw conclusions which may be helpful to areas faced with situations, similar to those in one or more of the countries studied. In Part II, each case is presented in a summarized form.

2. The range of the studies could not encompass all possible situations. This, however, may be covered in a later study. Although the silvicultural systems may be different within the Dipterocarp forests from those described in the study, many of the concepts will be similar and some, at least, of the conclusions will be applicable.

3. The selection of the countries to be included in the study was made with the object of encompassing as wide a range of management situations as possible. Thus, in Kerala and Trinidad, population densities are high, management of the mixed tropical forest and of plantations has operated for many years and the importance of the social and recreational role of the forests is well understood. In Ghana, the system of land tenure including private lands, tribal lands and State or Government lands complicate the management of both the mixed tropical rain forest and the savanna forests while in Honduras, management has only relatively recently been introduced to extensive areas of tropical pine forest in which it is hoped to integrate management with socio-economic development of the rural communities.

4. In each case, the backgrounds which have led to the development of management have been different as in the case of Trinidad where the harvesting of forest produce was oriented towards the domestic market whereas in Kerala, Honduras and Ghana (the savanna areas excepted) a factor of importance has always been the export market. In some cases success has been achieved in the management of the forests and in others management seems to be in decline. In many instances adaptations have had to be made to the form of management employed and frequently these adaptations have been dictated in response to social change. The results of these adaptations and particularly the application of the multi-use concept are examined below and attempts made to suggest the directions which future trends in tropical forest management will take.

CHAPTER 1

THE BACKGROUND TO FOREST MANAGEMENT IN THE STUDY AREAS

1.1 Location of Study Areas

5. The study areas are all located in the northern hemisphere and vary in latitude from $4^{\circ}44'$ N in the case of the most southerly part of Ghana to $16^{\circ}09'$ N which is the most northerly part of Honduras. All areas are therefore well within tropical latitudes. The most easterly area is that of Kerala which lies between longitudes $74^{\circ}51'$ E and $77^{\circ}24'$ E and the most westerly is Honduras which spans $83^{\circ}09'$ N to $89^{\circ}22'$ W. The longitude range therefore covers some 166° of longitude.

1.2 Climatic Variation

6. Temperatures are tropical varying from monthly means of about 25°C to 35°C except where moderated by altitude. Rainfall varies from a low of about 1 000 mm/annum in the savanna areas of Ghana to over 5 000 mm/annum in some of the interior forest areas of Kerala.

1.3 Area, Population and Population Density

7. Table 1 shows the area, population and population density in each of the study areas. In all cases, populations are estimated on the basis of the last census results.

Table 1
Area, Population and Population Density in each of
the Study Areas

| Study Area | Area (km ²) | Population | Population Density/km ² |
|------------|-------------------------|------------|------------------------------------|
| Ghana | 238 539 | 14 000 000 | 59 |
| Honduras | 112 100 | 3 800 000 | 34 |
| Kerala | 38 000 | 25 400 000 | 668 |
| Trinidad | 5 142 | 1 067 000 | 208 |

Thus, in the case of Honduras and Ghana, the population densities are low but in the case of Trinidad and Kerala, particularly, the population densities have had a very marked effect on the development of forest management and this matter will be referred to on a number of occasions in the following chapters.

1.4 Forestry in the Economy

8. Until the discovery and exploitation of oil in Trinidad about the turn of the Century the economies of all four countries were dominated by agriculture and the agricultural industries. Even today this remains true in Kerala where rice and other cereals, cashew, coconut and industries based upon renewable resources provide the basis of the economy, in Ghana where shifting cultivation provides the main source of food and employment and

cocoa and timber the main exports and in Honduras where agriculture provides the bulk of employment and sawn pine timber some 10% of the exports. Because of exploitation and refining of oil and, more recently, natural gas, Trinidad has steadily become industrialized and the importance of agriculture has continued to decline although the forestry sector has recently expanded largely because of teak plantations which are commencing to reach maturity and because of the willingness of Government to increase investments in watershed management, forest industries, plantations and forest recreation.

1.5 The Formal Establishment of the Forest Estate

9. Certain basic features must exist within a country before forest management can be instituted and develop in a rational manner. There must be a clear understanding of the general aims and principles which management seeks to achieve and there must also be a workable legal framework within which management can operate. These two factors are generally referred to as Forest Policy and Forest Law and are discussed in relation to the countries studied in the following chapter but here the concern is with the formal declaration that certain areas of a country will be legally recognized as being set aside and dedicated to the maintenance and management of tree crops in perpetuity. Such areas are generally known in English-speaking countries as Forest Reserves but of course may not, at the time of being given legal sanction, carry a crop of trees although the intention may be to establish tree cover as, for instance, in the establishment of plantations on land formerly classified as grass-lands.

10. In three of the countries studied, Ghana, Kerala and Trinidad, the establishment of the forest estates has followed roughly similar patterns although the time taken has varied considerably and circumstances have been different.

11. In that part of Kerala which was then Travancore, feudal and temple lands were gradually appropriated by the State in the early part of the 19th Century. The State was at that time under the direct influence of the East India Company and as the land was appropriated it was leased to tenants who paid taxes on the land. In 1816 a Conservator of Forests was appointed to assist the East India Company in the exploitation of the forests for such valuable hardwoods as teak and rosewood. Thus, from the early days of the nineteenth Century the forests were a source of revenue to the State in the form of taxes levied on tenants and from produce extracted by the East India Company. Transfer of power from the Company to the British Crown in 1858 resulted in the opening up of forest areas for the growing of tea, coffee, cardamom, etc. and in 1865 the Indian Forest Act made provision for the constitution of permanent forest reserves. The first reserves were proclaimed in 1887 and sporadic progress was made over the years. Today the total area reserved is stated to lie between 9 400 km² (24.2% of the area of the State) and 11 279 km² (29% of the State area) depending upon the basis of the computation, since a number of forest reserves have, in practice, been de-reserved although formal de-reservation proclamations have not yet been issued.

12. In Ghana a reconnaissance survey of the forest areas took place in 1908 and in the following year a Forest Department was established. The first priority of this Department was the reservation of selected areas of forest but since the colonial power (Britain) did not own the land, the opposition of the tribal chiefs (who were the recognized land owners on behalf of the tribes) delayed the reservation programme. During the first World War the Forest Department was closed down and it was not until 1919 that it was re-established and, with the cooperation of certain Chiefs, forest reservation commenced in 1920. By 1923 some 260 km² had been constituted as forest reserves, by the early 1930's 6 240 km² out of a target of 15 600 km² had been so constituted and today, 16 788 km² or 20.4% of the rain forest zone and 6 810 km² or 7.0% of the savanna zone are legally constituted forest reserves.

13. In Trinidad and Tobago the indirect benefits of the forest have always been well understood and given recognition. The oldest forest reserve in the Western Hemisphere was delineated in Tobago in 1765 by the French who designated the area now covered by the Main Ridge Forest Reserve as "Reserved in Forest for Rains". In 1880 an Inquiry was set up into "Forest Conservation and the Maintenance of Water Supplies", and three main headings were laid down under which conservation should be studied viz. forests with reference to:

1. water supplies and public health;
2. utilization of forest produce; and
3. reforestation of denuded lands.

A further overall study conducted in 1899 by a senior officer of the Indian Forest Service led to a report being presented to the Legislative Council in 1900 which dealt comprehensively with the principles of the conservation of soil, water and renewable natural resources. In identifying areas to be protected he explained that, as far as possible, these were restricted to poorer lands leaving the richer soils on more gently sloping lands for agricultural uses. In all, he identified 653 km² which should be protected for water supplies, 78 km² for fuel supplies and 28 km² for windbreaks. Thus, by 1900 some 15% of the country had been identified as potential forest reserves and when a forest officer was appointed that year one of the first tasks of the officer was to commence surveys of these reserves. In the next eight years the proposed reserves were surveyed and demarcated but formal proclamation did not take place until 1922. From then until 1960 the area of the legally constituted forest estate slowly expanded until the present extent of 1 267 km² (24.7% of the land area) was reached. Reservation has not yet been completed and the final percentage of the country legally constituted as forest reserves is likely to reach about 28%.

14. In the case of forest reservation in the three countries mentioned above, it can be seen that the legal constitution of the forest estate was a continuing process over more than a century in the cases of Kerala and Trinidad and some fifty years in the case of Ghana, that progress was not always steady but tended to be somewhat erratic yet in the end all three countries achieved a legally constituted forest estate of some 20-25% of the surface area of each respective country.

15. Honduras does not yet appear to have reached the stage of declaring a reservation programme for the whole of the country, but this is compensated by the fact that the Honduran Forestry Corporation has exclusive right to the management and utilization of all forests in the country. Forest lands are classified as private lands and national or municipal lands although investigations of one management area revealed that in spite of 24% of the area being registered as privately owned, some 41% was fenced and considered private by the local population. An additional complication is that an agreement, signed in 1980 between the Forest Authority and the National Agrarian Institute, seeks to define forest and agricultural land on the basis of land use surveys which have not yet begun and which will certainly take very many years to have an impact on any forest reservation programme.

16. In the case of the other three countries, surveys were certainly carried out but these were done on a pragmatic basis seeking to establish consolidated blocks of forest which may eventually cover some 20-30% of the country rather than an intimate mix of agriculture and forestry geared to each variation of site quality. Generally, enough is known about soil quality in a country to recognize which areas are unsuitable for permanent agriculture and this combined with such readily recognizable features as topography, slope, importance to the collection and regulation of water supplies, protection given from

prevailing winds, etc. are sufficient to indicate which areas should be formally recognized as forest reserves, especially if the selection is done in cooperation with agricultural and water authority representatives. The chief obstacle to such a pragmatic reservation programme is that of mobilizing the political will to sanction the programme and to take measures to compensate those whose interests have been infringed by the creation of forest reserves.

CHAPTER 2

THE INTER-RELATIONSHIPS OF FOREST POLICY, THE FOREST LAW AND FOREST MANAGEMENT

17. It has been suggested above that the existence of a legally recognized forest estate (or the stated intention to provide legal recognition) is one pre-requisite for the rational development of forest management. Two other factors are of equal importance to the development of long-term forest management. The first is a statement of Forest Policy to provide broad guidance concerning the direction in which Government (or other forest owner) expects management to proceed and the general goals to be attained and the second is the provision of a legal framework within which management can operate. However, a variation of these two factors occurs in the case of Honduras where Policy and the Law are much more closely interwoven and the operation and effect of these circumstances are contrasted below with that which pertains in the other countries.

18. In Kerala, before the constitution of the forest reserves, the local population was free to use the forests to satisfy its needs; but when revenue from the land became important, farmers were encouraged to convert forest land to agricultural use. The forest policy of 1894 stressed that forests could be justified only on the basis of indirect benefits to agriculture but by the time the 1952 National Policy was formulated the power-base of Government had shifted from agriculture to industry and trade and hence the influence of the wood-based industries became stronger. However, since Forestry remained a State matter and since agriculture was important to Kerala, policy directives of Central Government made little impact on forestry at local level. With the passage of constitutional amendments of 1976 and the Forest (Conservation) Act of 1980, which curtailed the State Government's powers to de-reserve forests a further impetus was given to the industrial orientation of forestry and a continuing trend away from multiple-use has become evident.

19. The 1952 National Forest Policy identified the following National needs:

- i) The allocation of land to the use for which it is most fitted;
- ii) The protection of catchment areas, the reduction of soil erosion and the protection against coastal erosion;
- iii) The provision of tree shelter to improve the environment and promote the well-being of the population;
- iv) The provision of increasing supplies of grazing, small wood for agriculture and fire-wood;
- v) The provision of a sustained supply of timber and other forest produce for defence, communications and industry;
- vi) The realization of maximum revenue consistent with the above.

20. The legal framework within which the forests of Kerala are managed are as follows:

- i) The Kerala Forest Act, 1961. This deals with the constitution of forest reserves, the duties and responsibilities of officials functioning under the Act, defines forest offences, lays down penalties for infringements and sets out procedures for bringing offenders to Court, etc. Rules are made under the Act to regulate the transport of forest produce, etc.

- ii) The Wildlife Protection Act, 1972. This prescribes rules relating to the hunting of wild animals and provides for the proclamation of national parks, game reserves, etc.;
- iii) The Cattle Trespass Act, 1971. This defines the procedure for dealing with cattle trespassing in forest areas closed to grazing;
- iv) The Kerala Forest Produce (Fixation of Selling Price Act, 1978). This regulates the price paid to the forest department for industrial wood to such industries as pulp and paper, plywood, matches, etc.;
- v) The Forest (Conservation) Act, 1980. Prohibits State Governments from de-reserving any forest reserve without the prior consent of the Central Government.

21. In the case of Ghana the indirect benefits conferred by the forest were recognized at an early stage and in the Statement of Ghana to the Empire Forestry Conference of 1928 it is stated "The Gold Coast (Ghana) has become to depend for its prosperity mainly on the cocoa tree and the cocoa tree depends upon the forest for the maintenance of soil and atmospheric moisture which are essential for its health". Other parts of the statement drew attention to the extent of soil erosion in the savanna zone, especially in the catchment areas of important rivers and the fact that streams were in spate after every rain yet dry soon after the rain ceased.

22. These concerns for the indirect benefits which the forest provides are reflected in the present forest policy, the important clauses of which are:

- i) The creation of permanent forest resources by:
the reservation of suitably situated areas of forest or land desirable and suitable for afforestation of a total extent sufficient to supply the benefits necessary for the welfare of the people including indirect benefits in the form of preservation of water supplies, maintenance of climatic conditions favourable to the principal agricultural crops and the control of erosion and to supply direct benefits in the form of sustained and adequate amounts of forest produce to satisfy the actual and potential requirements of the domestic and export market;
- ii) The management of the permanent forest estate to achieve maximum productivity and value in perpetuity;
- iii) The conduct of research into all branches of scientific forestry especially in ecology and silviculture in order to achieve the aim of Clause ii;
- iv) The cooperation with all agencies interested in optimum land use.

23. As in the case of Kerala, the forest legislation is no more detailed than is necessary to provide the legal background against which forest activities can operate and includes The Concessions Ordinance (1900), The Timber Protection Ordinance (1907), Rules relating to Property Marks and Timber Protection (1921) and The Forest Ordinance (1927). Because of opposition by the Chiefs and an educated elite to forest legislation, the initial Forest Ordinance of 1911 was withdrawn and greater provision made in the 1927 Ordinance and in the revised Ordinance of 1935 for participation by the tribes through their Chiefs.

24. In Trinidad and Tobago the broad outlines of a Forest Policy began to evolve in the early days of the present century and in 1942 Government formally adopted a Policy, the main elements of which included:

- i) The reservation of an adequate forest estate to ensure the direct and indirect forest benefits for the community;
- ii) The attainment of sustained yield of forest produce;
- iii) The promotion of the wider use of timber and the conduct of research in tropical forestry;
- iv) The provision of training for subordinate staff;
- v) The encouragement of private forestry and the co-operation with other agencies in promoting the wise use of land.

25. In 1915 the Trinidad and Tobago Forest Ordinance was enacted to provide the basis for the implementation of the embryonic Policy. The present Forest Act is the result of revisions and amendments made from time to time and is not dissimilar in broad outline to the Forest Acts of Kerala and Ghana in that it stipulates the general conditions for the cutting and removal of forest produce (detailed conditions being subject to separate Rules and Regulations made by the appropriate Minister and published as required), defines forest offences e.g. cutting or removal of produce without written authority, gives power of arrest to Forest Officers under defined conditions, gives authority to certain grades of Forest Officers to compound offences (i.e. impose penalties under strictly defined conditions if the offender is prepared to accept the penalty rather than appear before a magistrate), gives power to Forest Officers to demand production of written authority to remove forest produce and the power to seize tools, vehicles, etc. used in the commission of a forest offence.

26. Thus, in Kerala, Ghana and Trinidad, Policy is a fairly short and simple statement of the aims which management of lands dedicated to Forestry should achieve and the Forest Legislation provides only the necessary legal sanction for the actions which management must take to implement the Policy. It is now fashionable in certain quarters to deal with Policy in much more detailed terms but such discussions centre around policy options and how such options might be implemented. The fact remains, however, that the basic features of Policy as exemplified in the policies of Kerala, Ghana and Trinidad must be already accepted before detailed discussions concerning implementation can prove useful.

27. Although Honduras is a country with a long tradition in forestry due to the importance of its forest resources, policy matters became significant only after the promulgation of Decree 103 which established CONDEFOR. This law, by which CONDEFOR became a public service with considerable administrative autonomy, appropriate juridical status and financial independence, included among its objectives not only the protection, conservation and improvement of the national forest resources, but also conferred to CONDEFOR the responsibility for industrialization, commercialization and exportation. The Corporation can exploit and utilize the forest resources directly, through private or public enterprises, or through rural associations and cooperatives. The private owners may retain the property of their land, but not the forest resource itself, although they may receive incentives and payment for the forest products harvested on their land. The most important aspect in this law was the inclusion of a Social Forestry System which opened the possibility for rural people to participate in forestry activities (forest protection and regeneration, fire-fighting, etc.) and contribute to preventing excessive grazing and illegal harvesting. However, the inadequate regulations in this law, especially with regard to the Social Forestry System, have so far hampered any possibilities for rural people to participate in forestry activities other than those related

to resin-tapping. (Editor's note: since the writing of this paragraph, several advances have been made in respect of "people's participation". In 1983, the executive committee of COHDEFOR was restructured to include, among its members, a member of the Honduran Farmers Association and a member of the Honduran Woodindustries Association. The same year, a special Social Forestry Project was initiated with bilateral assistance, to formulate and demonstrate various options for people's participation in forest management. In 1984, recently drafted regulations of the forest law were approved by the president of the country and published in the Official Gazette).

28. The above-mentioned law further states that in forest areas where agricultural land use is advisable, COHDEFOR will cooperate with the National Agrarian Institute (INA) to determine their use for crops and cattle grazing. INA will allow permanent settlements of organized forestry groups and will promote social services and credit facilities to such groups for development purposes. In areas presently denuded of trees but destined for forestry, the law stipulates that COHDEFOR will develop agro-silvicultural projects in close association with organized groups of forestry 'campesinos' and in forested areas such groups will be given preference in harvesting including resin-tapping.

29. In 1980 an agreement was signed between COHDEFOR and INA defining forest and agricultural land and establishing cooperation between both Institutes in respect of a particular forest development project area, but since land use surveys have not yet commenced to identify land capabilities, no impact has yet been made on land use in the area.

30. Although COHDEFOR's law, as explained above, allows for the management of forest lands irrespective of ownership, no legal provisions exist to ensure the reforestation of privately owned land following harvesting of an existing timber crop. This deficiency severely limits sustained forest management and may already have caused a reduction in the area of pine forest. It is of immediate importance since much of the 1981-1985 reforestation programme in a priority forest management area is scheduled to be undertaken on privately owned land: if regeneration is not present prior to harvesting and if owners deny the right to reforest such land, the future of management in this area is in jeopardy.

31. From an administrative point of view, continuity of policy has been affected by frequent changes of the General Manager of COHDEFOR during the past eight years resulting in changes in policy to conform with the changing political atmosphere of the country. A further constraint to the implementation of policy is the infrequency with which COHDEFOR's Board of Directors meets. Although the Board is presided over by the President of Honduras and members are Cabinet Ministers thus ensuring authoritative policy-making and strong political support for the forestry administration, the very composition of the Board is such that meetings cannot be convened with a desirable frequency and a year may elapse between one meeting and the next.

32. Since Social Forestry is a stated feature of the Forest Policy in Honduras the findings of an FAO technical cooperation mission (TCP/HON/8906) in 1979 relating to an evaluation of the Forestry Social System are of interest. The conclusions included the following:

- a) Forestry organized groups do not have a clearly defined role in the primary objectives of COHDEFOR and as such these groups can become a hindrance to the achievement of such objectives;
- b) There is a need to define a co-operative model adapted to the Honduran situation including the aspirations of COHDEFOR and the Forestry Social System;

- c) The real and potential capacity of the forest to support its population needs to be established. CONDEFOR's law, in effect, proposes to incorporate man into forest development. This has a certain economic-productive limit since socio-economic problems cannot be solved by the forestry sector alone;
- d) There is an urgent need for participatory planning of the Forestry Social System groups. This lack of planning has been responsible for an average rate of desertion of 20% from these groups. Most groups are in a pre-cooperative stage, they do not own forest land or timber and lack of security has been a major cause of desertion or failure.

33. It must be remembered that, when comparing the policy and legal aspects of the four countries, three of them have been influenced intimately by the forestry outlook of one colonial power and have assimilated much of the legal system of that power. In the case of Honduras the legal and cultural background has been quite different and attempts have been made to speed up a process which in the other three countries proceeded at a more leisurely pace. It should, however, be made clear that no serious attempts to manage the forests of Honduras were made prior to 1974, when CONDEFOR was created and that this organization has introduced management principles affecting significant areas during the last 10 years. The inclusion of Social Forestry in the law should be seen as a determined effort of a government that the rural poor should participate in the wealth derived from the forests they live in or close to. This is a unique feature in forest policy in Latin America.

CHAPTER 3

FOREST MANAGEMENT

3.1 The Evergreen and Semi-Evergreen Tropical Broad-leaved Forest Under Protection, Selection or Shelterwood Systems of Management

34. For the purposes of this study it is proposed to follow the pattern set by Kerala, Ghana and Trinidad and accept that the evergreen mixed tropical forests are those forest areas receiving more than about 2 500 mm of rainfall each year and that the semi-evergreen forests are those receiving more than about 2 000 mm/annum and which merge gradually into the evergreen type as the rainfall increases. The areas on which both forest types are to be found are characterized by a high relative humidity.

35. In all three countries the structure and physiognomy of these forests are similar and the floristic composition of a heterogeneous nature. In Ghana, for instance, an average of 130 species of timber size are present in any one community; some 360 species have been recorded in the rain forest zone and of the 80 of these which reach merchantable size and in commercial quantities, harvesting is based upon only about 20 species. The forests exhibit a three-storey structure in addition to the ground flora and shrub layers. There is generally a lower storey of heavily branched trees of about 20 m height, an upper canopy of up to 40 m height and a discontinuous emergent layer of up to 65 m. In Trinidad, the heights attained are generally some 40% less in each of the three storeys.

36. In each of the three countries these forests are managed under systems in which varying proportions of the canopy are retained to provide soil protection, the regulation of water supplies and seed for the regeneration of openings which have resulted from the death of old trees or from the harvesting of desirable species.

37. There are three main systems under which these forest types are managed. There are those forest areas which are mainly inaccessible and are classified as Protection Forests. In these, the harvesting of trees is either not possible or is prohibited although minor forest produce e.g. reeds, canes, grasses, etc., are frequently collected. Secondly, there is the Selection System under which the harvesting of the forest is controlled by varying sets of prescriptions and thirdly there are adaptations of the Uniform System which evolved in Europe and which for many years was known as the Tropical Shelterwood System (TSS). There is no clear dividing line between the protection and the selection systems nor between the Selection System and the TSS as it has evolved and this merging of one system with the other is discussed below.

3.1.1 Management of the protection forests

38. In those areas where protection forests are well defined they generally form part of a working plan area in which the soil is vulnerable to erosion, e.g. very steep slopes or along water courses or alternatively areas which are inaccessible to normal harvesting methods. As such they are allocated to the Protection Working Circle, a working circle being a sub-division of a working plan area in which one type of management is prescribed. The objects of management in protection working circles are generally:

- i) To protect steep slopes and catchment areas and to regulate water supplies;
- ii) To provide minor forest produce.

When objectives are compatible, working circles may overlap as in the case of working circles dealing with the collection of minor forest produce. Thus, in the Quilon area of Kerala there are 1 784 km² of forest in which the Rattan Working Circle and the Minor Forest Produce Working Circle each cover the whole of the area and incorporate the Protection Working Circle (898 km²), the Selection Working Circle (655 km²) and the Reed Working Circle which covers all reed bearing areas.

39. In Ghana, a Protection Working Circle was designated in the 1952-57 Working Plan for the Kakum Forest Reserve but incorporated in the Selection Working Circle when the plan was revised for the period 1963-1978, although the protective role of the tropical high forest was a concept inherent in the plan.

40. Protection forests have never featured strongly in the management of Trinidad's forests, most sensitive areas being worked under a selection system but there were a number of nature reserves set aside to maintain the areas in a natural condition and these are now being incorporated in National Parks and Recreation Areas.

41. The trend most noticeable in relation to the management of protection forests is that of conversion to management under a selection system as in the case of Kakum Forest Reserve in Ghana and in Kerala, where improved access has made formerly inaccessible areas suitable for harvesting. These changes have taken place under economic pressure to make each area as productive as possible but occasionally the reverse may take place where forest worked under a selection system is found to be unsuitable for any sustainable use and then becomes classed as protection forest.

3.1.2 Management under the selection felling system

3.1.2.1 Objects and organization

42. Under the selection felling system the object in all three study areas is to harvest mature and over-mature trees of commercial value. In each of the areas some effort has been or is being made to augment natural regeneration where it is sparse or absent and to maintain the protective function of the forest. Trees harvested are selected on the basis of minimum girth limits and marketability. For organizational convenience the working circles in both Kerala and Ghana where selection felling is common, are divided into felling series.

3.1.1.2 Timber harvesting and regulation of the yield

43. The harvesting of timber on a sustained yield basis from a natural stand requires that the yield should be regulated to prevent over-cutting. Conceptually, harvesting is linked to the idea of rotational age but when trees are harvested as they approximate to maturity (e.g. in a polycyclic system in which the area is cut over at periodic intervals to harvest trees which have reached maturity since the previous harvesting) the rotational age has little relevance in deciding the time to harvest.

44. The period of the felling cycle is generally determined by the time taken by the pre-exploitable classes to reach the exploitable girth, set for each class of marketable species although where there are many over-mature trees the period may be shortened. In the study area of Kerala, the cycle has been prescribed as 15 years and the area cut over annually in each felling series (the annual coupe) is calculated by dividing the area of the felling series by the period of the cycle.

45. In fixing the minimum girth below which trees may not be exploited, market demands in Kerala were important and as demands for raw material increased there has been a downward revision of girth limits. Further precautions are exercised in the numbers of trees which may be removed per area unit and although methods exist which depend upon detailed knowledge of growth rates, mortality, etc. (e.g. Smythies Safeguarding Formula; see also below for the method used in Ghana) the number is generally fixed arbitrarily and varies between eight and twenty per hectare. Current views tend towards increasing the number per hectare removed at each cycle because of the increasing range of species which are becoming marketable, a factor of importance in the development of the Trinidad Shelterwood System which is discussed below.

46. Rules have been laid down for selection felling and in Kerala these prescribe that no tree within a radius of 20 metres of a marked tree should be felled, marking should be restricted to sound trees, felling should progress systematically through a coupe and that felling practices should aim at obtaining maximum output with least damage to the crop. (It should be noticed however, that no mention has been made of studies to determine the amount of felling damage in either Kerala or Ghana, a matter which has been shown to be of considerable importance in tropical high forest).

47. In practice, the number of marked trees felled and the species composition of the harvest from any one coupe is strongly influenced by the market and although working plans prescribe the spreading of the harvest over the various species, the market preferences are reflected in the species composition of the trees removed. Viewed objectively, the selection system practised in the evergreen forests of Kerala amounts to nothing more than the selective removal of commercial species having an immediate demand or, in other words, an extensive system of mining timber which takes no account of obtaining a normal forest with supportive regeneration of the commercial species.

48. In the study area in Ghana covered by the Greater Kakum Working Plan (1963), the total area of the Selection Working Circle amounts to 377 km² and this was divided into four felling series, each series corresponding with the total area of a timber harvesting concessionaire. The yield was regulated under a system in which trees of more than 1.5 m girth (48 cm dbh) would give equal annual yields for the period up to the time when the current immature trees attain exploitable girths. Volume tables are unavailable and basal area, which is believed to bear a direct relationship to volume in respect of trees over 3 m girth (95 cm dbh) was used. The time which trees take to pass from 1.5 m girth to exploitable size has been estimated as follows:

| | | |
|------------|-----------|----------|
| Class I a | 1.5 - 3 m | 60 years |
| Class I b | 1.5 - 3 m | 45 years |
| Class II a | 1.5 - 3 m | 50 years |
| Class II b | 1.5 - 2 m | 30 years |

The exploitable yield was calculated (the Kinloch and Jack method) by dividing the total hoppus basal area of all trees above 1.5 m girth by the time of passage. The calculated yield is justified by the forecast method of projecting the growing stock, less the annual yield, to the next felling cycle assuming a 75% survival rate. The felling cycle until 1971 was 25 years and the area of the annual coupe was obtained by dividing the area of the felling series by the period of the cycle. The yield was selected from the upper girth classes downwards until the prescribed yield was reached, minimum girth limits being enforced.

49. As an example of how this calculation was applied in practice the yield calculation for Class I species in the Gaisie Felling Series of the Greater Kakum Working Plan area was as follows:

| <u>Class</u> | <u>Species</u> |
|-----------------------------|------------------------------------|
| <u>Class I Species</u> | <u>Chlorophora excelsa</u> |
| | <u>Entandrophragma cylindricum</u> |
| | <u>Entandrophragma angolense</u> |
| | <u>Khaya ivorensis</u> |
| | <u>Tieghemella heckelii</u> |
| | <u>Nauclea diderrichii</u> |
| Net productive area of F.S. | 2 678 ha |
| Felling Cycle | 25 years |
| Annual Coupe | 107 ha |

Yield Calculations for Class I Species

| Girth (m) | 0.91-1.52 | 1.53-2.14 | 2.15-2.74 | 2.75-3.35 | 3.36-3.96 | 3.97-4.57 | 4.58 + |
|---------------------------------------|-----------|-----------|-----------|-----------|-----------|-----------|--------|
| No. of trees on 1 018 ha | 439 | 554 | 414 | 325 | 137 | 137 | 32 |
| Basal area (m ²) | | 147.4 | 195.8 | 240.2 | 145.8 | 198.5 | 60.9 |
| Total basal area (m ²) | 988.6 | | | | | | |

$$\begin{array}{lcl} \text{Estimated basal area on} & & \\ \text{F.S. of approx. 2 678 ha} & = & \frac{988.6 \times 2\,678}{1\,018} \text{ m}^2 \end{array}$$

$$\begin{array}{lcl} \text{Annual Yield by Kinloch and} & & \\ \text{Jack with 60 divisor (see paragraph} & & \\ \text{48 above)} & = & \frac{988.6 \times 2\,678}{1\,018 \times 60} \end{array}$$

$$= \underline{43.34 \text{ m}^2}$$

Apportionment of Yield

| Girth (m) | 1.53-2.14 | 2.15-2.74 | 2.75-3.35 | 3.36-3.96 | 3.97-4.57 | 4.58 + |
|------------------------------------|-----------|-----------|-----------|-----------|-----------|--------|
| No. of trees per Coupe of 107 ha | 58 | 44 | 34 | 14 | 14 | 3 |
| Basal area (m ²) | 15.49 | 20.81 | 25.19 | 14.90 | 20.34 | 5.67 |
| Yield of 43.34 m ² from | | | 2.43 | 14.90 | 20.34 | 5.67 |

i.e. all trees of more than 3.36 m girth plus 9.6% of the 2.75-3.35 m Class.

50. From 1970 the Reserve was subjected to salvage fellings of all trees above 3.36 m girth on a 15-year felling cycle in order to remove all over-mature trees. Prescriptions were made in the Working Plan for returns and controls to be compiled for areas exploited, volumes and species cut and volumes of defective trees. Rules were laid down for field checking and forest officers were required to maintain a series of registers, summaries of which had to be submitted annually to the Chief Conservator. Unfortunately, these records have not been kept up to date and it is therefore impossible to calculate the ratio of exploited yield to prescribed yield. In the period 1964-1968 the ratio fell from 38 to 12% of the yield offered probably because Class III species were then offered for the first time and few if any were cut. During this period approximately 55% of Class I and Class II offered were cut.

51. As a result of the introduction of salvage fellings to girth limits of 3.36 m on a felling cycle of 15 years, compared with the former cycle of 25 years, over-mature trees among the less popular species remained unexploited and in effect, the forest was more severely high-graded. The effects of this change are not yet known although a recently completed inventory may provide some information. Meanwhile, the feeling remains that salvage felling has led to over-exploitation of the economic species.

3.1.2.3 Concessions and royalty rates

52. Management within the Kakum Working Plan Area is affected by the efficiency of the timber concessionaires holding concessions and this in turn is influenced by the financial standing, equipment, training of the concessionaire's personnel and his ability to dispose of produce, especially timbers of Classes II and III. Existing concessions and felling agreements were largely negotiated before the imposition of more stringent conditions, which apply today, and were frequently influenced by the pecuniary and personal advantages derived by the Chiefs concerned. Concession rents are low, some areas are too small to provide continuity of exploitation and in some cases concessions have remained unworked while adjacent sawmills had insufficient raw material.

53. Royalty rates are uniform throughout Ghana and are based upon number of trees and species, regardless of volume. Rates range from US\$ 2.40 to 6.40 per tree and although the rates have been revised they are still considered too low in comparison with the value of the logs. Since royalties are not payable on trees rejected after felling, concessionaires reject trees which are only slightly unsound or damaged and no effort is made to salvage remnants.

54. Timber and the timber industries have contributed substantially to the foreign exchange earnings of Ghana and in the years 1976-1981, these earnings amounted to US\$ 4.9 million, 32.5 million, 43.3 million, 46.2 million, 39.2 million and 26.6 million respectively. A measure of the gains to the land owners may be obtained by comparing revenue, expenditure and disbursements to land owners of the Kakum Reserve in 1973-74.

(in US\$ equivalent)

| | |
|-----------------------------|--------|
| Revenue | 16 194 |
| Expenditure | 2 098 |
| Balance | 14 096 |
| Disbursement to land owners | 7 210 |

55. In Trinidad, selection felling is only carried out in areas which have not been designated for silvicultural treatment or for intensive harvesting under an annual coupe system. Control is by girth limits arbitrarily set for species classes and although it was an important form of management many years ago, precedence has since been given to intensive harvesting under area control. As stated in paragraph 37 above, there is now no clear dividing line between the selection system and the TSS and it is therefore proposed to discuss the intensive harvesting under area control as applied in Trinidad under the section dealing with the shelterwood system.

3.1.2.4 Silvicultural operations under the selection felling system

56. Silvicultural measures as a post-harvesting treatment in management under the selection system has been undertaken in a relatively small way in both Kerala and Ghana confirming the view expressed in the previous paragraph that the management boundaries between the selection system and the TSS are extremely blurred.

57. In Kerala, natural restocking after selection felling is inhibited by the absence of adequate regeneration of commercial species, heavy damage to poles and saplings during felling operations and invasion of openings by colonizing species, grass and sometimes reeds. In past years, prescriptions have been made for clearing undergrowth and dibbling in seeds of commercial species, patch weeding and the removal of unwanted growth, the planting of 'widlings' in selected sites and the continued maintenance of supplementary planting of nursery raised seedlings of desirable species. Currently an 'Intensification of Management' scheme is being applied over 40-50 ha of exploited forest under which weed growth is cleared, unwanted trees are girdled and seedlings planted at 2.5 m x 2.5 m. Deficiencies in the scheme include restriction of treatment to the first three years, failure to adjust the light reaching the seedlings by manipulation of the canopy density and restriction of the areas treated to a small fraction of the area exploited (in the Ranni Division, out of an area exploited of 4 925 ha between 1975 and 1981 only 90 ha were subjected to regeneration operations). Success depends not only on adequate financial provision but also upon close supervision at field level.

58. In Ghana, the approach to intensification of operations has varied from clear-felling and converting to plantations (which will be dealt with below) to efforts to widen the

range of species which are acceptable on the market, combined with measures to increase the numbers of "economic" species composing the post-exploitation crop. In the case of the composition of the "new" crop, improvement thinnings of various intensities were carried out all designed to favour the growth of the 'economic' species. Some 312 km² were treated annually between 1958 and 1971 when the treatment was discontinued because of grave doubts concerning the efficacy of the system, doubts which were reinforced when one of the species poisoned, Pericopsis elata, became one of the highest priced timber species. The TSS was also tried in efforts to secure desirable regeneration but abandoned because of the preponderance of non-commercial species regenerating and the paucity of the commercial species.

3.1.2.5 Management for non-wood products

59. In relation to the management of the evergreen and semi-evergreen forests Ghana has geared management almost exclusively towards timber production with scant attention given to the potential of minor forest products to stimulate rural industry and the use of rejected logs for a variety of purposes including fuel, charcoal, local crafts, etc. Only when the local population derives benefits from the forests will it cease to regard forests as "idle lands" and, in the view of the Forest Department, cease to regard the forests as land to be encroached upon when arable or orchard crop land (including cocoa) is required.

60. In India, minor forest products have always been important and when fire-wood, honey, wax, cardamom, rattan, reeds, etc. become commercially important, management for the product is dealt with separately by constituting a Working Circle for the management of the product. An instance of one of these products is cardamom (Elettaria cardamomum). During 1969-1973 the Forest Department raised 145 ha and in 1976 the Kerala Forest Development Corporation initiated a planting project which, together with the Forest Department plantation now extends to 1 625 ha. Long-term viability of cardamom cultivation depends (apart from favourable world prices) upon the maintenance of the appropriate micro-climate while the necessary weeding and cultural operations preclude the establishment of commercial timbers. This situation is almost parallel to that of Ghana where the forest is used to provide the micro-climate for the cocoa and since the latter is much more important economically than the forest shelter the latter becomes incidental to the cocoa in economic and management terms.

3.1.3 Management under the tropical shelterwood system

3.1.3.1 Objects

61. It has been shown above that neither Ghana nor Kerala were successful in obtaining adequate regeneration under the selection system nor, in the case of Ghana, under the TSS. In Trinidad, once success under the TSS had been achieved, the objects of management were briefly stated as the protection of the soil and of water supplies, the harvesting of timber on the basis of yield control by area and the establishment of a new crop of trees through natural regeneration under a shelterwood of mother trees.

3.1.3.2 Origin of the Trinidad TSS

62. The TSS in Trinidad evolved almost by accident. In 1926, an experimental plantation of Calophyllum brasiliense was established on brown sand in the Arena Forest Reserve. It was noticed that as clean weeding of the plantation proceeded the plants became chlorotic and when a ground cover was allowed to persist the plants improved. Clean weeding was suspended and natural regeneration began to appear. Over the years until about 1940 the TSS evolved as follows:

- | | |
|---------|--|
| Phase 1 | Pure plantations |
| Phase 2 | Plantations supplemented by natural regeneration |
| Phase 3 | Natural regeneration supplemented by planting |
| Phase 4 | Natural regeneration only. |

3.1.3.3 Management of Arena Forest Reserve under the TSS

63. The topography of the Reserve is gently undulating, the elevation varies from 30 to 60 m and the drainage is generally good. Much of the soil is of whitish to brown sand of low nutrient status which deteriorates further when exposed. The average rainfall is 2 400 mm per annum and the temperature within the forest varies from 19°C to 27°C. The vegetation is tropical evergreen rainforest of the Carapa Eschweilera type with a typical three-layer structure. Over-cutting of the durable hardwoods, e.g. Manilkara bidentata, Eschweilera subglandulosa, Tabebuia serratifolia, etc., had been severe.

64. During the period 1926-1931 management consisted of clear-felling and planting (see paragraph 69), mainly with Carapa guianensis and Calophyllum brasiliense resulting in the unhealthy growth already mentioned and severe attack on the Carapa by the shoot borer, Hypsipyla grandella. Clear-felled timber was sold if merchantable and charcoal burning before planting encouraged.

65. From 1932 onwards, timber felling and charcoal burning was so regulated that a shelterwood of dominants was left standing. Rules for the formation of the shelterwood were as follows:

- i) Cut vines 2 years in advance of shelterwood formation;
- ii) Harvest of mature timbers; leave as far as possible dominants of marketable species and remove only such dominants causing excessive shade even after removal of the under-storey;
- iii) Mark for felling all trees of the lower storey except where dominants or sub-dominants are absent;
- iv) If it is then desirable to remove additional dominants, such trees must be poisoned and not felled to avoid damaging adjacent shelterwood;
- v) Fell all palms.

66. Marketable trees which had been felled were extracted by bulls and species suitable for charcoal were converted in situ in earth pits (actually tightly packed short lengths of logs and branchwood stacked above ground and covered with soil). The average size of each pit was about 10 m³.

67. The regeneration was weeded from the 2nd to 7th year and supplemented by planting where necessary. As growth of the regeneration progressed the shelterwood was progressively removed by poisoning with a solution of sodium arsenite and thinning of the new crop undertaken when this appeared silviculturally necessary.

68. The Arena Reserve Working Plan for the period 1936-1945 prescribed annual coupes of 25 ha on a sustained yield rotational basis of 60 years but as the quantity of useful regeneration exceeded expectations a decision was made to expand the annual coupe even although this conflicted with the selected rotation of 60 years. This was encouraged by market conditions which, as a result of reduced timber imports during the war, allowed

the marketing of some fast-growing species and as the number of these increased so confidence in a shorter rotation, and hence a larger annual coupe became established.

69. In the early 1950's regeneration counts indicated that there was no apparent relationship between the species regenerating and those composing the shelterwood and since few species regenerating under the TSS in Trinidad have winged seed, the inference was that the regeneration came from seed already on the ground at the time of shelterwood formation and/or from seeds brought in by fruit-eating bats and birds. As market acceptance of fast growing 'secondary' species increased it became obvious about the mid 1950's that what was needed was a polycyclic system under which the fast-growing species would be harvested at the end of 30 years and the slower growing timbers would be allowed to grow on for a further 30 years during which time a second crop of fast-growing species would become established under those pole-sized slower growing trees remaining after the first harvesting. Under such a system, fast-growing species, e.g. Didymopanax morototoni, Byrsonima spicata, Sterculia caribaea, etc., would be cut at the end of the first thirty years leaving the slower growing traditional timbers as a shelterwood for a second generation of fast-growing species.

70. The effects of a change to a polycyclic system on the method of shelterwood formation was profound. Dominants were no longer retained for the shelterwood since satisfactory regeneration could be obtained from pole-sized trees which provided perching places for birds which congregated in the area of opened canopy and roosts for fruit eating bats. Such pole-sized trees were much preferred since they would remain sound for the 30-year cycle, all dominants could be harvested and the cost of later poisoning eliminated. Weeding costs were also reduced since the aggressively growing seedlings of the secondary species then becoming marketable could be left as a nurse crop for the slower growing, more shade tolerant traditional hardwoods.

71. The sequence of operations from the mid 1950's became established as (r - year of regeneration)

- r - 2 Vines cut
- $r - \frac{1}{2}$ Mature timber harvested
- r Shelterwood formed. Charcoal-burners operate in coupe
- r + 1 Clean weed to ground level. Woody growth of non-economic species retained (to discourage grass) unless interfering with valuable species
- r + 2 As for r + 1 but weeding not done to ground level
- r + 3 Vines cut. Non-economic growth reduced
- r + 4 Vines cut non-economic growth cut back.
Any shelterwood not to form part of the crop poisoned
- r + 5 Thin regeneration as required.

Supplementary planting was re-introduced in the 1950's but on this occasion the object was to introduce species (mainly exotic) not represented in the original forest rather than to obtain full stocking. Species planted included Simarouba amara, Chlorophora excelsa, Nauclea diderrichii, Terminalia superba and T. ivorensis. It is interesting to note that S. amara now appears (1983) in areas of regeneration far removed from the site of the original introductions.

72. Dramatic changes in silvicultural costs accompanied the changed technique. The average silvicultural costs for the first five-year period in the 1940-1942 coupes were 128 man days/ha and those for the 1950-1952 coupes, 26.5 man days/ha. A study of costs in 1957 revealed that the silvicultural costs throughout a 30-year cycle would amount to 60 man-days/ha and increment studies suggested that an average of 5 m³/ha/annum would be obtained.

73. As standards of living improved in Trinidad, charcoal was replaced as a fuel by kerosene and electricity and coal-burners progressively deserted the work. At Mount Harris, in 1953, where coal-burners were not available, the Arena technique was adapted as shown below. Following upon timber exploitation a shelterwood was formed by:

1. Under-brushing the area
2. Cutting all undesirable trees up to a diameter of 15 cm
3. Marking 70-80 pole-sized trees per hectare of desirable species (if available) for retention as shelterwood and poisoning the remainder.

Cleaning and weeding were carried out as described above for Arena and in 1957 the Annual Report stated that the results were comparable with those at Arena but that the additional cost of shelterwood amounted to 26 man days/ha. In other part of Mount Harris, where the forest had been badly depleted, direct sowing in lines cut at 6 m intervals was used to supplement regeneration and this method is now known as the Mixed Conversion System and is used on a limited scale.

74. In the North-East, Mora (Mora excelsa) forests exploitation was confined to annual coupes and intensive charcoal operations, following timber exploitation created a good shelterwood cover. No follow-up silvicultural operations took place yet a satisfactory new crop of mixed species became established through the agency of seed dispersal by bats and birds. At that time, there was great pressure from licensees for exploitation at a much faster rate than good management dictated and this was a prime reason of deliberately caused dry season fires, the logic being that fire-damaged trees outside the annual coupes would then be sold to licensees. The fires not only occurred in areas to be exploited in future years but spread to previously exploited coupes thus wiping out the regeneration. The soil of the Mora forests is almost pure quartzite sand and gravel and once the surface humus layer has been burned off, natural regeneration takes many years to become re-established. The situation became so difficult that a decision was made to plant up as much as possible with Pinus caribaea, happily, with satisfactory results.

75. Reference has been made in paragraphs 37 and 55 above concerning the merging of the Selection System into a Uniform System (or the TSS) and in the case of Trinidad the development from the TSS into an intensive form of harvesting and extensive regeneration based upon control by area. In this context, intensive harvesting is taken to mean exploitation confined to a definite area during a stipulated period of time e.g. an annual coupe or exploitation block in which trees to be harvested are selected with a view to encouraging a new crop and in which girth limits might be reduced for individual trees or species if this is in the interests of the succeeding crop. Thus, a fast-growing secondary hardwood species whose normal girth limit is 150 cm might have the girth limit reduced to, say, 120 cm to induce adequate opening of the canopy and also to harvest trees which would be over-mature at the end of the following cycle of, say, thirty years. The object would be to harvest the maximum possible volume consistent with leaving an adequate number of pole-sized trees to act as seed bearers, perching places for fruit-eating bats and birds and as the nucleus of a new crop. By extensive regeneration is meant the opening of

the canopy to encourage regeneration but allowing this to come through without further cultural operations.

76. At the present time, the ideas are still in the formative stage and a number of problems have still to be resolved. Although the intensive harvesting system in the North-East Mora forests appeared to lead to a satisfactory new crop of economic species, socio-economic problems arising from demand for more timber than the forest could produce on a sustained yield basis destroyed, through fire, the regenerating crop and led to the conversion of the forest to plantations. It remains to be seen whether, when improved access is created to the forests of the South-East a similar problem will develop. Will regeneration on soils which are much heavier than those of the North-East be sufficient to ensure a worthwhile second crop of timber? Will the felling cycle be long enough to permit a crop to reach maturity? Is this, indeed, a further extension of the case mentioned in paragraph 47 above in which the Kerala study claims that the system of selection felling as now practiced is nothing more than a system of mining timber which takes no account of the need for supportive regeneration of commercial species?

77. As originally practiced the TSS of Trinidad was a multi-use system of forest management in that the forest provided timber, fuelwood and charcoal, thatching materials and basket weaving fibres but as affluence and development increased, kerosene and electricity provided energy, corrugated galvanized sheeting and bituminous roofing materials replaced thatching in rural areas and plastics displaced much of the products of the weaving craft. As a result, the traditional multi-use role of the forest estate has largely disappeared although the greater mobility and affluence of the population had led to the increased use of certain forest areas for recreation and where this has occurred the role of the forest as a source of raw material has ceased.

3.1.4 Conclusions and discussions concerning the management of the evergreen and semi-evergreen forests including multi-purpose use

78. In Ghana, more intensive timber production hinges upon the use of "secondary" species especially on the domestic market to popularize these species and, temporarily at least, release more primary species on the export market. In addition, increased research into timber properties and preservation of the "secondary" species is required, maximum utilization of all trees felled should be encouraged and where feasible manufacturing plants should be set up near to the forest to reduce log transport costs and encourage more intensive utilization. The award of concessions should be contingent upon the ability of the concessionaire to establish a timber processing plant or link up with an existing plant and furnish proof of adequate financial backing. Royalty should be raised to a realistic level and should be based upon the volume utilizable in each royalty class rather than volume of each class extracted and consideration should be given to awarding concessions by auction. On the silvicultural side, and since improvement thinnings and the TSS have apparently failed, renewed investigation designed to produce statistically valid results upon which future silvicultural work will be based is urgently needed.

79. The management of the evergreen and semi-evergreen forests in Trinidad is completely different and reflects the socio-economic situation of the country. Many parts of the more remote areas are still worked under a fairly crude selection system which, in practice, is adequate but with a population density nearly $3\frac{1}{2}$ times greater than Ghana, forest management has tended to become progressively more intensive and those areas not destined for conversion to plantations are increasingly being placed under a system of intensive harvesting controlled on an area basis (see paragraph 75 above). However, since the country is also relatively affluent as a result of oil and natural gas, certain areas of evergreen forest are being taken out of timber production to provide national parks,

etc., which suggests that the Government is not only aware of the aesthetic value of the evergreen forest but is also able and willing to secure the retention of parts of the forest in the natural state. Elsewhere, forests are increasingly being converted to plantations yielding higher returns from species of proven worth.

80. To a far greater extent than the other two countries, Kerala indicates the future trends in management of the evergreen forests and the probable viability of the multi-use concept. Management of the evergreen forests is beset by many problems arising from the multiplicity of uses, the identification of appropriate alternatives for a given situation and the compatibility of some uses and the compatibility of others. Generally at low intensities of use two alternatives can be fully compatible but become incompatible at higher intensity of use.

81. Watershed protection is particularly sensitive to the intensity of wood production within the catchment area and especially when evergreen forests are intensively worked. The problem is to some extent overcome by zoning the most critical areas within a protection working circle and restricting wood production to the least critical areas. However, economic pressure for increasing supplies of timber frequently cause a downward revision of the area under protection by transfer to a selection system and the protective function is thereby diminished. Although there is a general management trend, because of economic pressure, from protection to selection to conversion to plantation systems, the reverse may occasionally take place where forest, worked under the selection system, is found to be unsuitable for any sustainable use and then becomes classed as protection forest.

82. The compatibility of wood production and that of minor forest produce again depends upon the intensity with which any one constituent of the forest is worked. In the case of cardamom production, it has been shown (paragraph 60) that the long-term prospects for wood production have been entirely subjugated to the production of cardamom, a situation similar to that which has arisen in the cocoa production areas of Ghana.

83. Management for sustained yield implies establishing a normal forest and harvesting should therefore eventually be confined to the equivalent of the increment. At the same time sufficient regeneration to secure the future crop must be established. But the present system seems to be oriented towards mining existing forests to meet the timber demands of industry (paragraphs 47 and 51) and regeneration has been almost wholly neglected. The sustainability of the selection system is therefore in grave doubt. Even assuming the area under selection felling remains constant, it appears that at each successive felling the yield will diminish and the structure and composition will be so altered that the yield will fall below acceptable limits. Alternatively the selection areas will be converted progressively to plantations and as accessibility to forest areas increases, the protection forests will be restricted to ridge tops and sites otherwise unsuitable for plantation forestry.

84. Ever-present, of course, is the threat to all forest land from agriculture and other non-forestry uses and population growth will aggravate the position. Short-term economic compulsion will influence the utilization of the evergreen forests and the trend is towards intensive single use management and away from management for multiple-use.

3.2 Conversion of Mixed Tropical Hardwood Forests to Plantations

85. Of the four countries represented in this study some degree of conversion of the mixed tropical hardwood forests has taken place in Trinidad, Kerala and Ghana. In the two former countries the work has been undertaken over a much longer period of time than in Ghana and the approach has been more systematic. The main study in this section will

therefore be confined largely to Trinidad and Kerala although reference will be made to Ghana in relation to attempts to satisfy local demand for agricultural land by the introduction of the taungya system spread diffusely throughout the forest area.

86. In both Trinidad and Kerala, the preferred forest type for conversion to plantations is the moist deciduous forest with an annual rainfall of from 1 500 mm to 2 000 mm although examples are to be found where conversion to plantations has taken place outside the upper or lower limits of this range. The soils selected are generally dependent upon the requirements of the species to be planted and in the case of teak (Tectona grandis) and Caribbean pine (Pinus caribaea) (the two main species discussed) the former prefers a clay loam of pH 5.9-6.3 and the latter a sand or sandy loam of pH 4.8-5.5. The account which follows outlines the conversion of the mixed hardwood forests of Kerala and Trinidad to teak plantations followed by an account of conversion of the forest to pine plantations in Trinidad.

3.2.1 Teak plantations: management objectives and organization

87. The principal objectives of management in the conversion of selected forests to plantations is the improvement in the value of the forest and hence the enhancement of potential revenue to the maximum, consistent with good forestry practice. In the case of both Kerala and Trinidad, the preferred plantation species has been teak because of its value and suitability for a wide range of uses, because of its freedom from serious problems related to disease or pests and because establishment and maintenance techniques are simple and investment requirements relatively low. As industrial demands for timbers with different characteristics and properties increased, so the species favoured for plantations widened to encompass those suitable for pulp, matches, low and medium quality veneers, and in Trinidad, a locally grown replacement for imported coniferous timber.

88. Working plans for areas to be converted generally include, in both countries, two main working circles. In Kerala, the Plantation Working Circle includes all areas already converted to plantations and the Conversion Working Circle which is composed of those areas yet to be felled and planted. In Trinidad, the Conversion Working Circle is composed of those areas already converted to teak plantations plus those areas scheduled for conversion during the life of a current working plan and the Exploitation Working Circle is composed of the bulk of the forest lying outside the plantations, much of which will later be converted to plantations. In both cases the area of the Working Circle into which the plantations fall expands either annually or at each working plan revision and the area of the Working Circle yet to be converted (and which is generally worked under a selection system) is reduced correspondingly. In each country smaller working circles may cover, for example, the Protection or Nature Reserve. Working circles may also be delineated according to local conditions and management objectives. Each Plantation Working Circle is divided into an appropriate number of felling series and each felling series into a number of compartments and sub-compartments.

3.2.2 Agro-silviculture in relation to teak plantations

89. Prior to the introduction of teak to Trinidad, agro-silviculture had flourished in Trinidad for many years as part of the management system for cocoa plantations. Plantation owners leased plots of land for several years to agricultural workers who cleared the forest, planted cocoa and used the area for growing their own food crops during the period of the lease, moving on to a new area when the cocoa was established and receiving some payment for the work done. This system bore strong similarities to the taungya system under which teak plantations were formed in Burma and was readily adapted to teak planting in Trinidad, the main differences being that the lease was for one growing season only

(15 months to allow for felling, burning, planting and reaping of the food crops) and that no payment was made. However, the Forest Department was responsible for fire-tracing, burning and planting and the taungya farmer had a virgin piece of land for his crops each year. An analysis of the economics of teak plantations shows that, in the example quoted for Kerala, the Net Present Value on the basis of costs and benefits at a discount rate of 5% was Rupees 6 664/ha (approximately US\$ 670/ha) when the plantations had been formed without the assistance of taungya farmers and Rupees 9 226/ha (approximately US\$ 920/ha) when taungya farmers were employed.

3.2.3 The importance of seed source in teak plantations

90. In the case of the teak plantations of Kerala, local seed sources were used and the question of provenances did not arise. Trinidad was fortunate that the original importation from the Tenasserim region of Burma made in 1913, flourished under local conditions. Additional importations were made in 1915 and 1916 but germination from these batches was, in each case, very poor. The plantations of Trinidad are therefore virtually derived from the 1913 importation although a small amount of seed was obtained from India in the mid-1930's for experimental purposes. No seed collections are made from the experimental plot derived from the Indian seed because of the poor form and growth exhibited compared with that of adjacent areas. From 1918 onwards plantations were formed entirely from seed produced by trees derived from the 1913 importation. What was not realized at that time was that the early flowering and seeding of these very young trees were genetic characteristics of the individuals and that the early terminal flowering causes bifurcation of the main stem to take place. Thus, in the early years what happened was, in effect, a positive selection for the production of short-boled trees because of the genetic character controlling early flowering. Even today, the plantations of the 1920's frequently have poor form and for many years this was believed to be due to the wider spacing (up to 3.5 m x 3.5 m) at which the plantations were formed. The inferiority of the early locally produced seed now seems a more likely reason.

91. The genetic quality of seed produced improved gradually as thinnings eliminated badly formed trees and in 1960 seed stands were designated after close examination of all stands of 25 years and over. By that age a well thinned stand has been reduced from 2 500/ha to some 200-250/ha and only trees of good form remained. Thus, the genetic quality of seed from the seed stands of the Trinidad teak plantations is now high. Unfortunately, the same mistake is being repeated in many countries who fail to understand the importance of obtaining seed from more mature teak trees of good form than those early flowering trees which they themselves possess and from which they collect seed as a means of reducing costs.

3.2.4 Plantation establishment with teak

92. The establishment of teak plantations in Kerala and in Trinidad follows similar patterns although details vary in each of the two territories. Taking Kerala as the example, conversion is effected by clear-felling the forest and planting on a rotation of 60 or 70 years, the area of the annual coupe being arrived at by dividing the total plantable area by the number of years in the rotation. This theoretical annual coupe which would eventually produce theoretically equal annual yields is seldom attained and the preponderance of younger age classes reflects a progressive expansion of the annual rate of planting, especially during the 1960's and 1970's, when improved access provided much larger areas suitable for conversion. The situation is similar in Trinidad although the expansion took place in the 1950's and 1960's.

93. Preparation for planting commences with the marking of all valuable species above 120 cm girth in the original forest some two years prior to planting, the felling of these trees by contractors appointed by the Forest Department and the removal of logs together with fire-wood to the departmental timber depots where sales take place. In the second phase, all residual tree growth and lop and top down to 30 cm girth at the small end is removed after auction, the slash distributed over the area and the coupe completely burned before handing back to the Department. On well stocked areas some 80 m³ of timber and 120 m³ of fire-wood pre-hectare is obtained but this falls to about 40 m³ and 80 m³ respectively on poorer sites.

94. Nursery site preparation involves the formation of raised beds 15 m x 1 m, dug to a depth of 30 cm and supported along the sides by split bamboo and stakes. Seed sowing is dictated by the pre-monsoon showers of April-May; no pre-treatment is carried out in Kerala and germination takes place in about two weeks. The germination percentage varies from 60 to 80% and one bed is sufficient to provide plants for 0.5 ha. Stumps consisting of 2-3 cm of shoot and 15-20 cm of tap root are cut just before planting, i.e. one year after sowing.

95. After burning the coupe (paragraph 92) the planting spots are marked out at 2 m x 2 m and once the pre-monsoon showers have started in May, the stumps are planted by opening a hole with a crowbar or similar tool and firming-in the stumps.

96. Immediately after planting the area is leased out in blocks of about 8 ha to co-operatives or individuals prepared to undertake taungya i.e. the cultivation for a limited period of agricultural crops and the simultaneous maintenance of the teak. Rules relating to weeding, tending, fire-protection, the food crops which may be grown, etc., are laid down in the contract and the rental for the lease fixed. Where taungya is not possible three weedings are carried out in each of the first two years and two in the third year. During the first three years of a plantation raised without taungya the cost is some Rupees 2 850/ha (approximately US\$ 285/ha) whereas the cost with taungya is Rupees 1 250/ha (approximately US\$ 125/ha) and when the revenue from rental is taken into account the cost of establishment is almost eliminated.

3.2.5 Post-establishment operations in teak plantations

97. In Kerala, post-establishment operations commence in the 4th year when the first thinning is carried out and thinnings repeated in the 8th, 13th, 20th and 44th years. The first two thinnings are systematic (or mechanical) and reduce the crop to 1 250/ha at the first thinning and to 625/ha at the second. All subsequent thinnings are selective and aim at producing an even distribution of the crop, the retention of healthy dominant trees, the removal of all dead or suppressed trees and the felling or pollarding of inferior tree species interfering with the teak. Branches infected by mistletoe (Dendrophthoe falcata) are removed and burned. Thinnings are carried out with reference to the All India Yield Tables and the general 'rule of thumb' is that in the early stages of a plantation, the spacing should be about 1/3 of the average height. For comparison with Trinidad, an Annual Programme (a synthesis for illustration only) for that country is included in Table 2 showing expenditure heads against which the several types of work would be charged.

Table 2

Annual Programme for the Year ... 1963

(Trinidad and Tobago)

Working Plan Central Range Reserve

Working Circle Teak Conversion Felling Series Mount Harris

| <u>Coupe</u> | <u>Compartment</u> | <u>Net Area</u> (ha) | <u>Prescription</u> | <u>Rate</u> | <u>Cost</u> |
|-------------------|--------------------|-------------------------|--|--------------|------------------|
| | | | | T & T \$ | |
| 1955 | 13 | 25 | No work | - | - |
| 1956 | 14 | 25 | No work | - | - |
| 1957 | 15 | 28 | Mark thinnings | 18.00 | 504.00 |
| 1958 | 16 | 30 | Fell thinnings | 22.00 | 660.00 |
| 1959 | 17 | 35 | No work | - | - |
| 1960 | 18 | 40 | Weed teak | 30.00 | 1 200.00 |
| 1961 | 19 | 40 | Weed teak | 35.00 | 1 400.00 |
| 1962 | 20 | 40 | Weed late in year | 40.00 | 1 600.00 |
| 1963 | 21 | 40 | Fire-trace and burn. Lift teak stumps and plant at 2.5 m x 2.5 m | 50.00 | 2 000.00 |
| 1964 | 22 | 45 | Survey compartment, locate nursery, clear-fell and burn, form seed beds, sow seed and weed in September | - | 3 000.00 |
| <u>Other work</u> | | | | | |
| | i) | | Fire protection in plantations | | 2 000.00 |
| | ii) | | Purchase and maintenance of tools | | 1 000.00 |
| | iii) | | Maintenance of buildings | | 2 500.00 |
| <u>Roads</u> | | | | | |
| | i) | | Cutlass and maintain inspection paths | | 600.00 |
| | ii) | | Maintain plantation road | | 2 000.00 |
| | iii) | | Extend plantation road by 500 m | | 4 500.00 |
| | | | | Total | 22 964.00 |

98. Thinning yields obtained from plantations in the Konni Division of Kerala are as follows:

| Age (years) | Yield (m ³ /ha) | | |
|-------------|----------------------------|--------|--------------|
| | Poles | Timber | Total volume |
| 4 | 0.439 | - | 0.439 |
| 8 | 2 646 | - | 2 646 |
| 13 | 4 381 | 0.005 | 4 386 |
| 20 | 6 865 | 0.180 | 7 045 |
| 30 | 7 328 | 1 591 | 8 919 |
| 44 | 7 808 | 4 610 | 12 418 |
| Total | 29 467 | 6 386 | 35 853 |

3.2.6 Final fellings and yields in teak plantations

99. In all Divisions in the study area of Kerala, with one exception, the rotation adopted is 70 years and is aimed at obtaining trees of over 180 cm girth (57.3 cm diameter) although it is only in Site Quality Class I that the maximum number of trees of this size is obtained. Table 3 illustrates this point.

Table 3
Crop diameter (cm) and percentage of trees
above the exploitable diameter of 57.3 cm
(Kerala)

| Age | Site Quality | | | |
|-----|--------------|-----------|----------|----------|
| | I | II | III | IV |
| 50 | 55.4 (36) | 39.9 (2) | 26.4 (0) | 17.0 (0) |
| 60 | 60.7 (59) | 45.0 (4) | 30.0 (0) | 19.0 (0) |
| 70 | 65.3 (80) | 49.3 (8) | 33.3 (0) | 20.8 (0) |
| 80 | 69.0 (88) | 53.5 (25) | 36.8 (0) | 22.9 (0) |

Source: F.R.I. and Colleges (1970). Figures in parentheses represent the % of stems above exploitable diameter.

Based on total volume, the age of maximum volume production varies from 5 to 15 years depending upon the site quality. Taking stem-wood volume alone, the mean annual increment culminates at age 50 years on Class I sites and age 75 on Class II sites. When the 70-year rotation was fixed, the demand for large size timber was strong and poles were of little value. The situation has changed and poles and small timber earn substantial revenue and one Division has already reduced the rotation to 60 years and a further

reduction is possible. The average yield from final fellings in the Konni Division (see paragraph 98 above for intermediate yields) averages 88.86 m³/ha of timber and 47.79 m³/ha of billets.

100. The total yield obtained from thinnings and final fellings in the Konni Division averages 172.32 m³/ha on a rotation of 70 years which gives a mean annual volume of 2.46 m³/ha. The total yield and MAI shown in the All India Yield Tables for site qualities I to IV are:

| <u>Site Quality</u> | <u>Total Volume</u> | <u>MAI (m³/ha)</u> |
|---------------------|---------------------|-------------------------------|
| I | 610 147 | 8 716 |
| II | 450 263 | 6 432 |
| III | 293 178 | 4 188 |
| IV | 141 342 | 2 019 |

When the yields from the Konni plantations are compared with the All India Tables they generally fall below Class III. The low yield is primarily due to a low out-turn of thinnings suggesting poor stocking during the establishment phase but when the yield from final fellings alone is considered the out-turn approaches Class III quality.

101. Growth and yield data for Trinidad teak plantations are illustrated in Figures I and II. Figure I shows the total volume of the crop including thinnings and Figure II the Mean Annual Increment (MAI). The results illustrated by these curves are not wholly indicative of the crop. Frequently, sample plots from which the data were obtained are located on better than average sites within the compartments and in recent years routine thinnings have fallen behind schedule although sample plots have been thinned and measured. Thus, it appears that the sample plot results over-estimate the volumes of the surrounding crop and this excess is probably in the region of 10-15%.

3.2.7 Costs of establishing teak plantations

102. It has been shown in paragraph 96 above that in Kerala, the net cost of establishing teak plantations is virtually nil when the land is leased to taungya farmers. In Trinidad the situation is very different and plantation establishment is becoming more expensive due to the lack of farmers prepared to undertake taungya contracts, although a subsidy of T&T \$ 120.00/ha is paid to contractors who accept such contracts. This situation has arisen because of the drift from agricultural and forestry pursuits in favour of employment in industry. Table 4 lists the costs in man days/ha up to and including the first thinning for plantations formed without the assistance of taungya farmers.

Figure I
Teak in Trinidad
Total volume-age

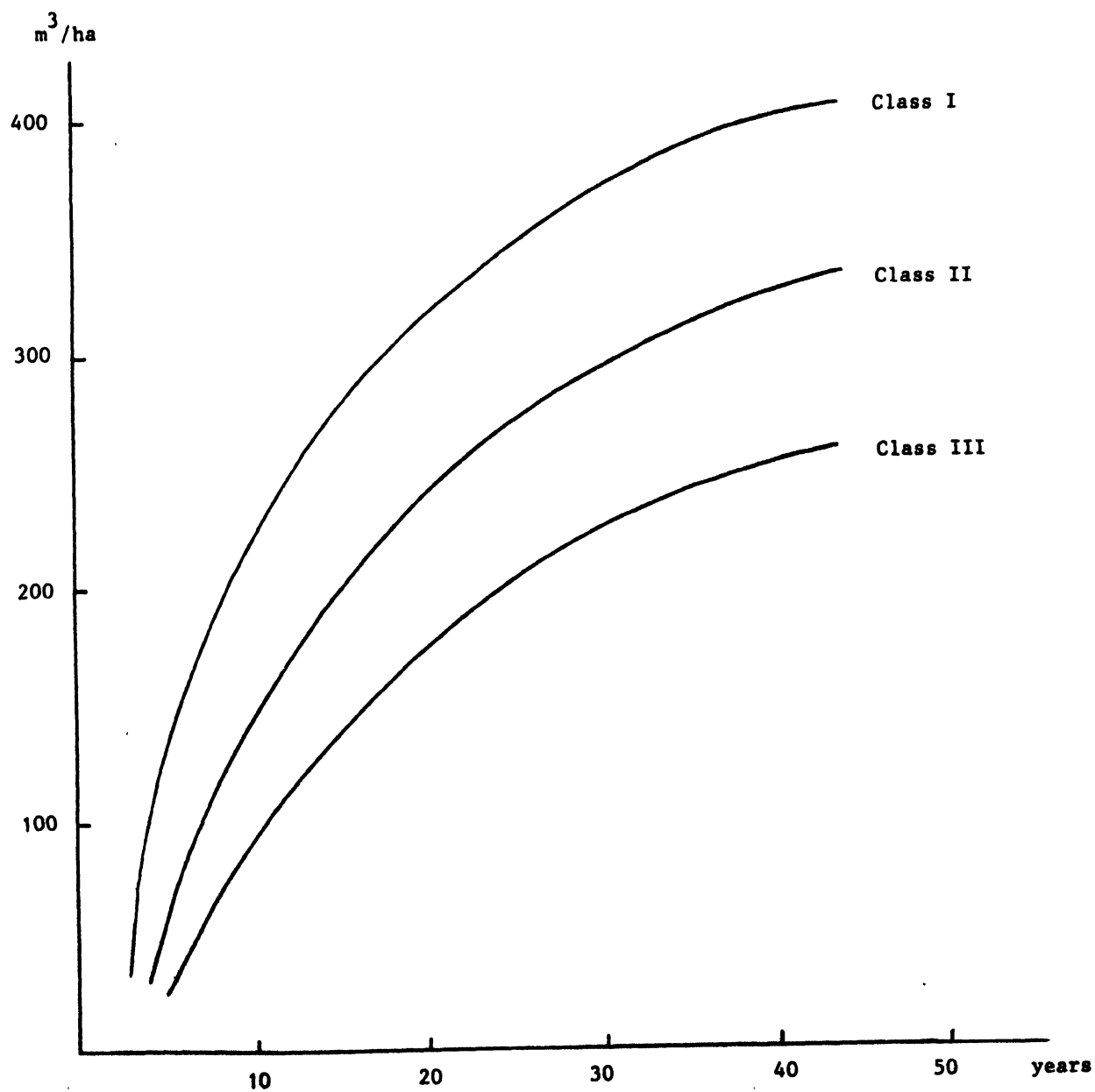


Figure II
Teak in Trinidad
Mean Annual Increment-Age

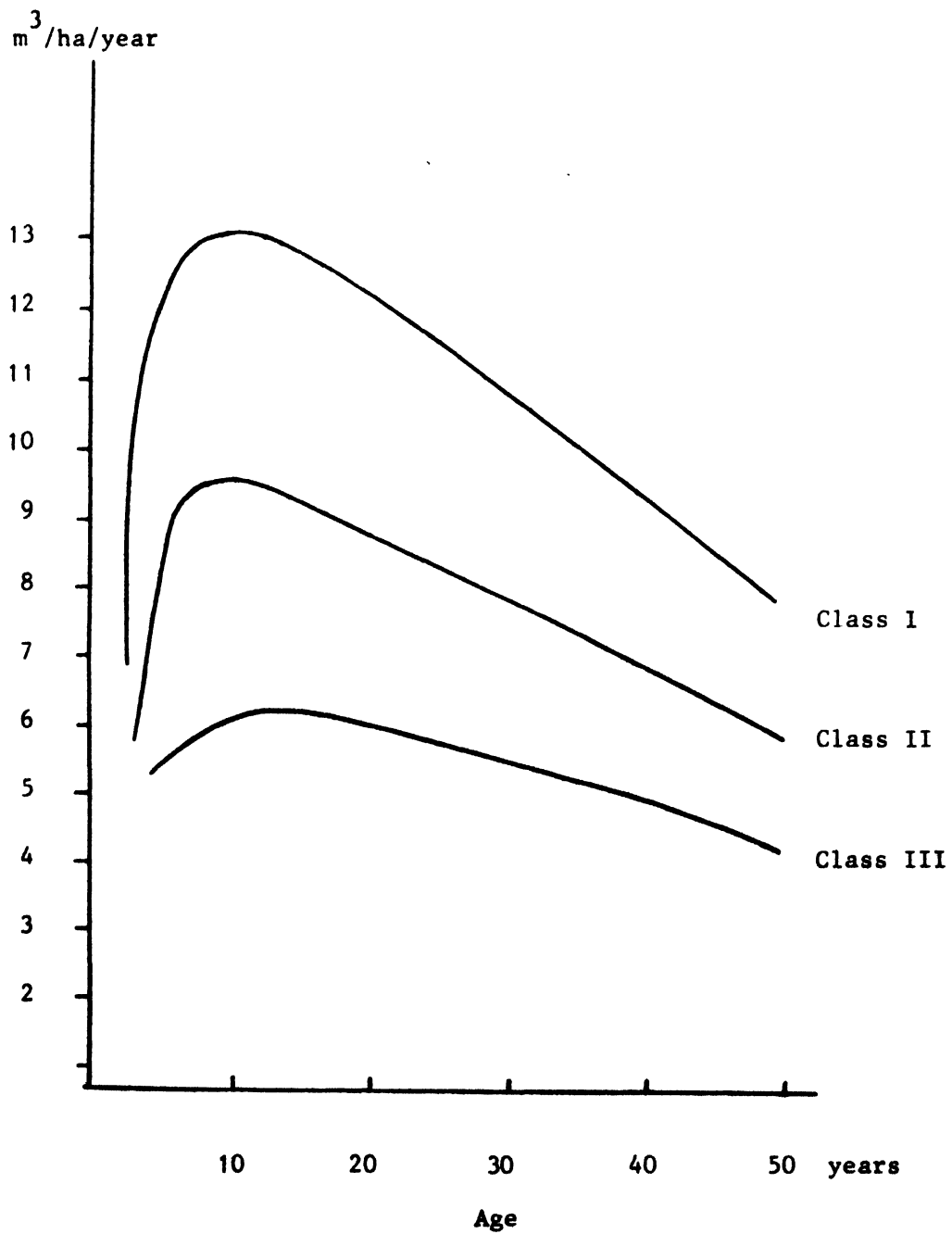


Table 4

Average Costs (man days/ha of plantation) of Establishing Teak Plantations
(Trinidad and Tobago)

(Year of Planting = P)

| <u>Year</u> | <u>Work done</u> | <u>man days/ha</u> |
|-------------|--|--------------------|
| P - 1 | Under-brush nursery area, clear-fell, fire-trace and burn. Dig drains, form beds and sow 15 cm x 15 cm. Weed plants and remove doubles | 15 |
| P | Under-brush, clear-fell, fire-trace and burn | 22 |
| | Lift nursery plants and form stumps | 3 |
| | Plant stumps | 8 |
| | Weed and replant blanks in September | 12 |
| P + 1 | Weed plants | 12 |
| P + 2 | Weed plants | 12 |
| P + 3 | Weed plants | 7 |
| | Mark for thinning | 4 |
| P + 4 | Thin crop | 5 |
| Total | | <u>100</u> |

The total cost amounts to 100 man days/ha up to and including the cost of the first thinning.

3.2.8 Potential developments in the management of teak plantations

103. In both Kerala and Trinidad, the techniques for the establishment and management of teak plantations have stabilized. Yet, particularly in the case of Trinidad, changes have been suggested (but not yet implemented) which could greatly modify existing techniques. In the late 1960's the studies leading to provisional yield tables for teak in Trinidad (which included Figures I and II above) suggested that when the crop reaches 7.5 m height the stocking should be reduced to 960/ha and when the basal area built up to 18.6 m²/ha a second thinning should reduce this to 11.3 m²/ha and that when the basal area again built up to 20.1 m²/ha a final thinning should reduce this to 14 m²/ha.

104. Proposals made in the mid 1950's involved the reduction of the crop by much heavier thinnings at the fifth and tenth years to 350/ha at the age of 10 years, i.e. about four times the final crop, followed by high pruning of half of the 350 trees/ha to a height of 5.5 m. The aim of these proposals was to induce rapid early growth and from the tenth year produce knot-free timber for sliced veneer in the two basal logs. Now that high quality seed is available from seed stands initial wider spacing also becomes a possibility.

105. An extension of wider spacing at planting was developed in the early 1960's when the teak was planted in groups, each group containing nine trees to provide competition within the group and the groups spaced at 5.3 m x 5.3 m. The intention of this procedure was to provide better conditions for the taungya farmers, to simplify thinning procedures

by reducing each group of nine trees to two trees at the first thinning and to one tree at the second thinning. At the spacing chosen between the groups four times the final crop would be left after the second thinning. Results after the first thinning were excellent but due to the changes in personnel and shortages of staff, the trial proceeded no further. It was also clear that the number of trees planted in each group could, with advantage, be reduced to five trees.

106. One factor of great significance has emerged in Trinidad from the introduction of Caribbean pine (Pinus caribaea) into teak coupes at the time of planting. When planted on or near the flat tops of undulating land teak grows poorly (almost exclusively Class III quality) but on such sites pine has grown extremely well. In future the teak should be confined to the slopes and the poorer tops reserved for pine. The species are compatible since they are both resistant to fire and there is every indication that the pine will remain healthy for a 50-year rotation of teak. Alternatively, and depending upon market conditions, the pine could be felled at 25 years to produce two rotations of pine during one rotation of teak.

107. Mention has already been made (paragraph 99) of the decision in at least one division of Kerala to reduce the rotation of the teak from 70 to 60 years as a result of the changing demands of the market. The yield table studied in Trinidad discusses options concerning the age at which clear-felling should take place and points out that if Class I teak is felled at the age of 50 years, the stumpage value would amount to T&T \$ 2 500/ha. If this sum were invested at 4% it would appreciate to T&T \$ 8 100 by the year 80 whereas if the crop were allowed to grow on to age 80 years the stumpage value would increase to only T&T \$ 3 370/ha. Alternatively, the stumpage of teak vis-à-vis rotation age three courses are open. These are:

- a) Clear-fell at age of 50 years
- b) Allow to grow on and accept a poor return, if percent stumpage prices are kept
- c) Allow to grow on and increase the stumpage substantially.

Although these matters became clear in the late 1960's decisions have still to be made on which option will be applied.

3.2.9 Conversion of mixed hardwood forest to plantations of other hardwood species

108. In Kerala the term "softwood" is generally applied to non-durable timbers primarily utilized in the match and plywood industries. The important species raised are Bombax ceiba, Ailanthus triphyssa and Eulodia anukenda. The softwoods are either raised in intimate mixture with teak in which case the teak and softwoods are spaced at 2.5 m x 2.5 m or as a pure crop spaced at 4 m x 4 m. Weeding is carried out as for teak and thinnings made at the 8th and 13th years. The rotation vary from 30-40 years and it is expected that the crop will reach 150 cm girth in this time. Yield tables are not available. The performance of Bombax in mixture with teak has not been satisfactory largely because of different growth characteristics. Ailanthus is now planted extensively by the Kerala Development Corporation and is a useful species for farm lands and homesteads.

109. Eucalypts were first introduced into the Kerala area in 1960. The main species have been E. grandis and E. tereticornis and with the establishment of a Forest Development Corporation in 1975, plans were made to convert 13 000 ha of moist deciduous forest to eucalypts to provide the raw material for wood pulp. The plantations are managed on a coppice rotation of 8 years and the annual increment has varied from 5 m³/ha to 35 m³/ha on the best sites. The average yield is much less than expected with incorrect choice of sites, faulty management, fire and disease affecting results.

110. Small-scale plantations of mixed hardwood species have been established in Trinidad but these have been of minor importance compared with the plantations of teak and Caribbean pine. However, a lesson was learned in Trinidad some 70 years ago. In 1908 plantations of Cedrela mexicana, Swietenia mahagoni and C. alliodora were commenced and by 1912 some 56 ha had been formed. Although destroyed by fire that year it was evident that success was unlikely because of damage caused by a shoot-borer (later identified as H. grandella) on the Meliaceae. Examples of such damage is evident in most countries from Australia westwards to South America when the Meliaceae have been used as plantation species.

111. In order to meet the demands of local population for land, the taungya system was introduced in Ghana on a widely distributed basis which complicated management and had limited success. Large-scale plantations were therefore commenced in 1968 and by 1977 some 40 000 ha had been laid down; but the success rate did not exceed 60%. The annual planting target from 1980 was set at 10 900 ha. The major species used have been Terminalia ivorensis, Cedrela odorata, Gmelina arborea, Tectona grandis, Mansonia altissima, Triplochiton scleroxylon, Tarrietia utilis, various Eucalypts and pines of which Pinus caribaea var. hondurensis has done best. None of the valuable and indigenous export timbers have performed well in plantations either because insect attack, e.g. the Khayas and Chlorophora, or because of difficulties in procuring a regular supply of seed, e.g. Triplochiton.

112. Reforestation involves clear-felling, burning and planting blocks of pure species. The implications of this system in relation to the effects on the environment, e.g. soil deterioration and the incidence of insect attack are now being studied. Also, a programme of study has been undertaken, to determine the extent to which agri-silviculture can be applied to reforestation and to quantify the benefits to be obtained.

3.2.10 Conversion of mixed hardwood forest to pine plantations

113. Pinus caribaea was first raised in Trinidad in 1948. Experiments on nursery and plantation techniques began in 1950 and the first routine plantations were established in 1956. Available information and experimental plots showed that the best growth was obtained on sandy soils with a pH in the range 4.8 to 5.5 but reasonably good growth was also obtained on silts and on quartzite sands and gravels. All forest reserves in Trinidad have a suitable rainfall pattern and the pine has grown on sites varying from flat to steeply sloping with good results. Areas planted are all below 300 m elevation. It quickly became obvious, that the species was strongly fire-resistant especially after the age of four years, a factor of great importance in Trinidad.

114. The planting of pine is not yet done under formal working plan control and plantations are formed as fast as funds will permit, there being large areas of degraded forest available and suitable for conversion to pine plantations. Control of all work involved in the establishment and maintenance of all the plantations is effected through annual programmes drawn up for each plantation centre.

115. In the nursery, seed are broadcast in germination boxes filled with medium grade sand and lightly covered with gravel. Germination takes place in about 5 days and, when they can be handled, seedlings are transplanted into 7.5 cm diameter black polyethylene bags filled with a topsoil mix to which 10% micorrhizal soil has been added. The transplants are hardened-off under sarlon netting during a two-week period. The netting is then removed and watering and weeding carried out as necessary. Sowing commences in October of the year prior to planting and is continued as necessary until about February and the ideal nursery product is a plant of about 23 cm with a high root to shoot ratio.

116. Site preparation is similar to that of teak, i.e. merchantable timber is sold in the year prior to planting, the area under-brushed, clear-felled, fire-traced then burned towards the end of the dry season. Planting is carried out at 2.5 m x 2.5 m spacing and weeding done as required. The annual programme has the same layout as that shown above for teak plantations at Table 2 and the cost in man days/ha to the end of the first 5 years is shown in table 5. The total cost for this period amounts to 134 man days.

Table 5
Average Cost (man days/ha of plantation) of Establishing
Pine Plantations
(Trinidad and Tobago)

(Year of Planting = P)

| <u>Year</u> | <u>Item</u> | <u>Man days/ha</u> |
|-------------|--|--------------------|
| P | Under-brush, clear-fell, fire-trace and burn | 22 |
| | Cost of plants | 32 |
| | Planting pine | 11 |
| | Weed and fill blanks | 15 |
| P + 1 | Weed | 15 |
| P + 2 | Weed | 15 |
| P + 3 | Weed | 12 |
| P + 4 | Weed | 12 |
| Total | | 134 |

117. Data concerning growth rates are sparse but twelve sample plots have been laid down and measurements made at regular intervals. Height/age classes have been identified and are shown in part 2 of this study. The mean annual increments of the classes have not reached peaks at age 20. At age 20 years, the mean annual increments vary from a low of 11 m³/ha to a high of 18 m³/ha. Thinning schedules are still under discussion with the question of an assured market for the thinnings being a problem still to be solved.

118. Apart from sample plot measurements, research work relating to pines has concentrated on tree improvement and the initial work which began in 1959 was concerned with plus trees. The criteria applied were:

- a) Stem form (straight)
- b) Vigour
- c) Branching habit (light regular branching with a wide branch angle)
- d) Good seed production

The dangers of selection from immature stock and from plantations extending to only 200 ha was understood but the aim was to perfect techniques as early as possible and to continuously extend the selection. Cuttings, air-layering and various types of grafting were

employed to provide material for a clonal garden which was established with replicates of clones of 18 trees. In 1968 a seed orchard was commenced and grafting of stock plants continued until 1972 when 584 ramets had been established.

3.2.11 Potential developments in the management of pine plantations

119. Regeneration by converting moist deciduous tropical forest to pine plantations is now averaging some 260 ha/annum and during the past 10-15 years nursery and establishment techniques have stabilized. To an even greater extent than with teak, post-establishment management will have to concern itself with the timing and intensity of thinnings (little of which has been done) and the economics of the operation. The cost of timber obtained from thinnings cannot compete with the present cost of imported pine, but since the mean annual increment peaks at about 25-30 years of age increment loss will soon become significant if the older compartments are not thinned. Studies made in 1969 in connection with the compilation of yield tables suggested that rotation age would most probably be 30-35 years and proposed that the simplest method of controlling a thinning programme for pine would be to allow the basal area to build up to about 31 m²/ha and to reduce this to about 22 m²/ha at a first thinning and thereafter to permit the basal area to attain 33 m²/ha then to reduce this at a second (final) thinning to 26 m²/ha. The matter of thinning pine plantations is now urgent and decisions should not belong delayed.

3.2.12 Conclusions and discussions concerning the conversion and management of natural forest to plantations with special reference to multiple-use management

120. The case study of the conversion of natural forest to plantations using taungya in Ghana as a means of satisfying the demand from local inhabitants for agricultural land brings out clearly that scattered plantations are extremely difficult to manage. The presence of taungya farmers seems to complicate management and demands a high degree of close supervision to ensure that under-brushing and felling are completed in good time to ensure a 'hot' burn of the felled area, that food plants are restricted to those which do not damage the tree crop and that adequate tending is undertaken to ensure that the tree seedlings are not smothered. With taungya scattered throughout an area of forest the necessary supervision becomes very difficult and the 60% success achieved is a reflection of the difficulties encountered in this respect.

121. Mention has already been made in paragraph 102 of the difficulty now being experienced in Trinidad in recruiting sufficient numbers of taungya farmers for plantation formation even although a subsidy of T&T \$ 120.00/ha is being paid. This situation reflects the general drift from agricultural pursuits to the service and manufacturing industries in which work is less arduous and remuneration higher. Accompanying this drift, the role of the forest in providing minor forest produce has been greatly reduced in that fire-wood and charcoal are no longer extracted or produced from each annual coupe during clear-felling operations and fibres and thatching materials ignored. The multi-purpose role of the forest, especially during the period of conversion to plantations has greatly diminished and if affluence, based upon the production of oil continues, it would appear that the former multi-purpose role will disappear entirely.

122. In Kerala, multiple-use in plantations is limited to the cultivation of feed crops under the taungya system in the younger plantations. Indications suggest that taungya, especially when tapioca is cultivated with the teak have deleterious effects on the soil but they have not been quantified and taungya with tapioca is likely to continue in Kerala. To improve the productivity of land under teak, a 5-year scheme was commenced in 1976-1977 which envisaged the planting of pepper, cocoa and medicinal plants in those plantations which had received a final thinning. By 1982, 287 ha had been established in three

Divisions. The expected internal rate of return of 15% has not been realized and the annual income/ha falls very short of that expected. Apart from a deciduous species like teak being unsuitable as a shade tree for cocoa, it is clear from the better performance achieved by small farmers from intercropping, that success is due to the personal attention given to all cultural operations and that this cannot be achieved under institutional control. Due to the unsatisfactory results the programme is now shelved and this aspect of multi-use discontinued.

3.3 Management of the Savanna Forests

3.3.1 General.

123. The only savanna forests of the study areas are located in the northern zone of Ghana under relatively harsh climatic conditions. The mean daily maximum temperature is 35.4°C, total precipitation varies from 1 000 to 1 250 mm/annum which falls between May and October followed by drought from November to April during which relative humidity remains at less than 30% at 15.00 hours each day. The unfavourable rainfall pattern coupled with dry season fires exerts a degrading influence on the vegetation and shifting cultivation aggravates the situation. Under these circumstances the protection role of the forest is of major concern. The zone covers an area of some 156 880 km², i.e. about two-thirds of the area of the country. The land use pattern may be summarized as follows:

| | | |
|-------------------------|------------------------|-----------------------|
| Forest reserves | 8 810 km ² | (5% of area of zone) |
| Unreserved woodlands | 84 800 km ² | (54% of area of zone) |
| Grass-land, farms, etc. | 62 670 km ² | (41% of area of zone) |

It is estimated that some 380 km² of forest and woodlands is lost annually to shifting cultivation and other forms of land use.

3.3.2 Structure and composition of the savanna woodland

124. The tree vegetation is typically short, heavily branched and widely spaced over a ground flora of tall grass. Two zones are distinguished, the Guinea Savanna of the South and the Sudan Savanna of the North. In the South the Guinea-type shows graduations into the Antiaria-Chlorophora Association of the high forest but further north trees are more widely spaced, shorter and with semi-xerophytic and xerophytic species becoming more prominent. The Sudan Savanna zone is restricted to the North-East and woody vegetation is represented by: Balanites aegyptiaca, Adansonia digitata, Sclerocarya birrea, Bombax costatum, Acacia spp. and Combretum spp.. Within each zone local variations due to edaphic and biotic factors occur.

3.3.3 Reservation, protection, wildlife conservation and exploitation

125. Forest reservation within the zone is limited to some 5% of the area and the major forestry operations consist of protection of the natural forest and the establishment of plantations. Early burning of the natural woodland is seen as the most appropriate method of protection and of improving the growing stock although the complete exclusion of fire, if this were possible, seems to be the most effective method of improving the stocking of woody vegetation. The other related activity is that of wildlife conservation and the Mole Game Reserve covering 4 940 km² is the first game reserve in the country and provides a habitat for numerous species of indigenous fauna. In addition, the Bui National Park of 2 080 km² is located in the savanna woodlands.

126. The sawn timber requirements of the area are obtained from the high forest zone of the South and the major use of the savanna woodlands has been for the supply of poles, fuelwood and other minor forest produce. The out-turn of fuelwood in the northern and upper regions in 1976 was estimated to be 1.48 million m³. Minor produce includes grass for thatching, the shea nut, Butyrosperma paradoxum for shea butter, Adansonia digitata for sugar substitute and the fruits of Parkia filicordia for soups.

3.3.4 Management within the Red Volta Reserve of the savanna woodland zone

127. The Red Volta Forest Reserve lies in the Navrongo District of the upper region and forms a belt along the west bank of the Red Volta River then subsequently along the north bank of the White Volta River up to the Tamale Bolgatanga motor road. The area of the Reserve is 2 625 km² and the population density in the vicinity of the Reserve rises from about 50/km² to some 200/km² in farming areas. The population is agricultural, raising food crops at subsistence level; a few farmers maintain fairly large herds of livestock and the large-scale cultivation of rice and maize has placed pressure on woodland areas. Farming methods are permanent around the scattered compounds with shifting cultivation and short fallow periods further afield. The major river valleys are not generally cultivated because of the deteriorated soil and health hazards associated with sleeping sickness and onchocerciasis.

128. Apart from farming, employment opportunities are limited and rural industries are centred around carving, weaving and leather work. Per capita income is low and migration to the South in search of employment is common. The supply of fuelwood in the zone is inadequate and domestic energy requirements are frequently met from corn stalks and occasionally cattle dung. Woodland degradation has reduced stocks of tall thatching grasses generally and the reserves are becoming the only source of this material.

129. The reserve was demarcated in 1948 as a production reserve for poles and fuelwood for the surrounding population, a 1% enumeration was carried out in 1951 and between 1952 and 1960, 708 ha were planted with T. grandis, A. leiocarpus, D. sissoo, G. arborea, M. incrimis and G. mexicana. The latter, which is a high forest species was tried on level soils but generally it failed. The major operation currently undertaken is early burning and the Forest Products Research Institute has established trial plots of several species, particularly acacias for gum production. Planned exploitation was never implemented, maintenance of reserve records has been poor and the most recent statement of accounts (1976) shows a debit balance of Cedis 21 309.52 (approximately US\$ 8 124).

3.3.5 Conclusions and discussions concerning the management, including multi-use of the savanna woodlands

130. The reservation programme as originally planned was designed to protect the courses of the major rivers and some success has been achieved in this direction yet only 6% of the total area is under reservation. This percentage is very low in view of the degradation of the woodlands outside the reserved forests.

131. The intangible benefits which the reserve confers cannot be quantified and are probably not appreciated by the surrounding population whose main interest lies in financial gain and the reserve does not seem to have provided this. No records of disbursement of revenue to land owners (whose land forms the reserve) exists and the debit balance of US\$ 8 124 up to the end of 1976 suggests that there never will be one. Under these circumstances the land owners must view the reserve as idle land which could be put to profitable use. It appears therefore that the management of the Ghanaian savanna woodland has borne no recognizable benefit to the local population and one solution might be the introduction of more intensive multiple-use forest management directed towards improving the living standards of the adjacent community.

3.4 Management of the Tropical Pine Forests of Honduras

3.4.1 General

132. The economy of Honduras is based primarily on agriculture and forestry which together constitute about one-third of the gross domestic product, four-fifths of the exports and provides two-thirds of the employment. Exploitation of the pine forests has been inefficient and highly selective leading to depletion as access to the forests is developed. The area of the forests amounts to 64 000 km² of which 20 000 km² are broad-leaved, 24 000 km² are coniferous and 20 000 km² mixed forest grass-land and forest fallow. The broad-leaved forests are generally located in areas to which access is difficult and because of low yields of commercial species and high harvesting costs exploitation is extremely limited. The pine forests, however, are widely exploited and the production of sawn timber is the principal forest industry. Between 1979 and 1981 inclusive, hardwoods exploited amounted to 105 000 m³ while the volume of pine harvested totalled 3 128 million m³. Inefficient harvesting and transport difficulties cause only 50% of the net commercial volume larger than 15 cm u.b. to reach the sawmill where wasteful production techniques result in one-third of the input being converted into sawn wood. Nevertheless, the forestry sector has been a traditional source of employment in the manufacturing area and the pine forests provide 97% of the raw material which generates this employment. In the period 1969-1973, before COHDEFOR was created, 2.7 million m³ of pine were harvested on the average each year, of which 59% was exported in log form and the remainder supplied 140 local sawmills. Studies revealed that only 12% of the harvested volume was converted locally into sawn wood and that the price per cubic metre of harvested logs ranged from US\$ 0.05 to US\$ 0.09 and that exports were declared at only 47% of value resulting in only 45% of real foreign exchange earnings accruing to Honduras.

133. Under the direction of COHDEFOR, log harvest has now been reduced to around one million cubic metres per year, log export is no longer permitted, the standard of several sawmills has been upgraded and new, modern mills have been introduced. All forest districts have been divided into management units and management plans of various levels of detail and management intensity drawn up for 14 forest management units, covering a total of 900 000 ha or roughly 37% of the coniferous forests of the country. Las Lajas is one of these management units.

3.4.2 Description of the study area: The Las Lajas Forest Management Unit (LLFMU)

134. The LLFMU covers 77 598 ha in the central portion of Honduras and for administrative purposes is divided into sub-units, viz. Las Cruces (19 344 ha), Las Lajas Central (16 998 ha), Valle Grande (15 018 ha), Yure (15 276 ha) and Agua Blanca (10 962 ha). Elevation varies from 130 m to 1 733 m and four categories of terrain have been defined ranging from easy to inaccessible to describe the accessibility. It is estimated that under present harvesting systems, 25% of the area is inaccessible and 57% can be classed as "easy".

135. About half of the area is of volcanic origin, one quarter is of calcareous rocks of marine origin and the remainder of limestones and heterogeneous rocks including sandy and conglomerate quartz. Soils vary from shallow with a pH of about 5.0 to fertile alluvials suitable for intensive agriculture. The climate of the LLFMU has an average rainfall of 2 100 mm/annum, a four-month dry season from January to April and average dry temperatures vary from 22°C in January to 27°C in May.

136. The area under pine forest in 1980 amounted to 39 059 ha and under agriculture to 19 891 ha. Agriculture has been expanding at the expense of the hardwood forests but as accessibility to these becomes more difficult, the pine forests will come under increasing pressure especially in the Las Lajas Central Unit where the terrain and soils are suitable for agriculture. Of the pine forests 48% are privately owned and 52% are in public ownership. Studies have shown that the average holding is less than 2 ha/owner, a significant proportion of families are landless thus creating pressure on the forest for land and that there is a need to incorporate the local population into forestry or agro-forestry activities.

137. Interpretation of aerial photographs combined with a forest inventory reveals the distribution of pine trees of a minimum height of 3 m, a minimum crown cover density of 20% or a minimum of 10 trees/ha as:

| | | |
|--------------------------|-----------|-------|
| Areas under regeneration | 5 500 ha | (14%) |
| Established regeneration | 10 000 ha | (25%) |
| Young stands | 4 000 ha | (10%) |
| Mature stands | 20 000 ha | (51%) |

The species composition within the study area is as follows:

| | | |
|----------------------------|-----------|---------|
| <u>Pinus oocarpa</u> | 24 747 ha | (62.7%) |
| <u>Pinus caribaea</u> | 10 841 ha | (27.4%) |
| <u>Pinus pseudostrobus</u> | 3 925 ha | (9.9%) |

| | | |
|-------|-----------|--------|
| Total | 39 513 ha | (100%) |
|-------|-----------|--------|

138. The total underbark log volume was estimated to be 2 213 million m³ of which 92% occurs in stands with 25 m³/ha, the amount of defect increases significantly beyond the age of 60 years and the annual increment of all trees of more than 10 cm girth totals 41 270 m³.

139. A socio-economic study made in 1978 revealed that the population of the management unit was 9 360 persons, the literacy rate 49.6%, 84% of the families owned their own home, 76% of all families had no running water and gastro-intestinal disease, especially of the young, was rife. The main occupation was subsistence farming (36%) and for those working for a salary the average monthly remuneration amounted to US\$ 52.16 while those not salaried earned an average of US\$ 27.35 per month. Some 56% of the energy required for lighting and cooking is based upon fire-wood from pine and broad-leaved trees followed by 32% for kerosene. Based upon the national average, some 12 500 m³ of fire-wood is used annually in the LLFMU area. A significant proportion of agricultural land is held by small farmers owning less than 3 ha each, 48% of the population have no land for permanent crops and 32% have no land for annual crops. Land ownership is complicated and registration of titles inadequate. In the LLFMU area only 24% of the land is registered as private land yet 41% is fenced and considered private by the local population. The law empowers the Honduran Corporation for Forestry Development (CONDEFOR) to manage all forest land independently of ownership but rights to timber are vested in the owner and up to 40% of any stumpage fees charged by CONDEFOR can be returned to the established forest owner as payment for his timber.

3.4.3 Forest policy and management in the LLFMU

140. The situation relating to Forest Policy and Forest Legislation has been discussed in paragraphs 27-32 above and the objectives relating to technical forestry have been incorporated in a management plan drawn up for the LLFMU area for the period 1980-1985.

141. The long-term objectives governing the management of the forests of the LLFMU have been identified as follows:

- a) The attainment of sustained yield in perpetuity;
- b) The harvesting of the present mature and over-mature forests to be regulated to provide a constant yield during the next 10-year period to stabilize supplies of raw materials to industry;
- c) Fire-wood and other domestic timbers to be supplied as far as possible from non-commercial timber or from stands specifically designated for the purpose;
- d) Grazing to be controlled to safeguard the other objects of management;
- e) Management to give priority to soil and water conservation in areas where such needs are critical.

142. In view of the prescriptions contained in the law (paragraph 28), consideration had to be given to how best to incorporate social objectives in the management of the area. However, the problems of acceptable land use in relation to the destructive methods of agriculture as practiced over much of LLFMU, land occupation and validity of tenure, grazing, fire protection and the directives of the law are such that rational objectives and the means of attaining these will have to be evolved for social forestry within the management unit. Until this is possible, studies to identify the means of attaining the objectives of social forestry must continue (see paragraph 27).

143. Each of the sub-units listed in paragraph 134 have been divided into compartments on the basis of the uniformity of the potential use of the crop (pine forest, hardwood forest, protection forest, etc.), the area required to constitute a logging unit handled by one landing and accessibility of the whole compartment to tractors and to existing road network, etc. The area covered by the average compartment is about 100 ha.

144. Inventory of the management unit suggested a total standing log volume of 2.213 million m³ and the distribution of the volume in mature stands is shown in table 6.

Table 6
Mature Stand Areas and Volumes per Sub-Unit

| Sub-Unit | Log volumes | | | |
|-------------------|-------------|-----|------------------------|-----|
| | Area (ha) | % | 1 000's m ³ | % |
| Las Lajas Central | 5 136 | 20 | 427.8 | 22 |
| Valle Grande | 3 512 | 13 | 274.4 | 14 |
| Yure | 6 186 | 23 | 471.3 | 24 |
| Agua Blanca | 2 825 | 10 | 164.6 | 8 |
| Las Cruces | 9 287 | 34 | 609.2 | 32 |
| | 27 176 | 100 | 1 947.3 | 100 |

The usual compartment descriptions were compiled in Registers (area, soils, slope aspect, etc.) and details entered on a base map.

145. Investigations revealed that maximum yield is obtained at about 50 years of age in the natural forest and it seemed logical to assume that in managed forests subject to cultural and thinning operations, such yield would be attained in some 45 years. This period was therefore chosen as the rotation and a theoretical area control of 1/45th of the productive forest calculated. Because of such factors as over-maturity, accessibility, density of stocking, etc. flexibility of harvesting had to be attained even although the theoretical annual coupe as calculated amounted to 866 ha.

146. The inventory also revealed that the sub-stratum of the forest with the largest trees (i.e. those stands with dbh greater than 35 cm) covered 22 799 ha and by dividing this area by the area of the theoretical annual coupe (866 ha) the Conversion Period was obtained, thus:

$$\frac{\text{Mature Pine Forest Area}}{\text{Annual Coupe}} = \frac{22\,799}{866} = 26.3 \text{ years}$$

The volume within the mature pine areas was estimated, from inventory results to be about 1 248 782 m³ and on the basis of a conversion period of 26.3 years, the annual yield would therefore be:

$$\frac{\text{Volume on Mature Area}}{\text{Conversion Period}} = \frac{1\,248\,782}{26.3} = 47\,482 \text{ m}^3/\text{year}$$

If the merchantable top diameter is increased from 15 to 25 cm, the available volume is reduced to 37 063 m³/year.

147. The selection of the actual locations to be harvested during the current period of the management plan (1980-1985) has been influenced by accessibility to existing roads and to two established circular sawmills. For these reasons the sub-units Yure and Las Cruces have been selected. The average annual harvest area in these sub-units is 18% higher than the theoretical annual coupe and the volumes to be harvested some 15% lower than the volumes theoretically available. These differences are due partly to earlier selection felling in some of the areas and partly to a lower stand volume than the average calculated in these sub-units.

148. Apart from regulation of the yield the LLFMU Plan prescribes for the usual 'Other Operations' including harvesting of seed trees and thinnings, regeneration operations including natural regeneration, direct seeding, planting nursery work, fire protection, road infrastructure annual programming and a revision of the plan towards the end of the five-year period.

3.4.4 Conclusions and discussions concerning the management of the natural pine forests of Honduras including multi-use of the forests

149. Unlike the case studies in the other three countries in which management of the forest estate has been conducted for many years the case study of Honduras can only consider the legal, social and policy environment in which management operates and, to a very limited extent, the hopes and aspirations as expressed in one management plan. The emphasis which the country wishes to place on 'social forestry' is very clear, yet the difficulties are many and are encapsulated in the comments of the FAO Mission quoted in paragraph 32 above. The management plan for the LLFMU area faced up to these problems and admitted that the means of attaining social forestry had yet to be identified (paragraph 142 above). The plan therefore proceeded to formulate a traditionally technical management plan in which some prominence was given to the concept of multi-use and social

forestry by attempting to organize the traditional occupation of resin-tapping for local inhabitants wherever possible, and in cooperation with INA, conduct land use surveys.

150. The type of management proposed in the LLFMU management plan now serves as a model for 2 930 km² of forest in Comayagua, 350 km² in the North-West District and some 7 000 km² of Olancho and Yoro forest districts. It is important, however, to point out that the Las Lajas model has still to find means of successfully incorporating social forestry and implementing multiple-use factors which are not only important but which have been emphasized in the Legislation/Policy.

151. The sawmilling industry remains highly selective in resisting the harvesting of logs below 30 cm diameter and in working only in areas with a commercial volume of 30 m³/ha or more. If this practice continues, the productive pine forests of Honduras (Olancho Forest Reserve excepted) will have an average life of only some 15-18 years. There seems no alternative therefore, to the imposition of a rational system of harvesting followed by effective regeneration and management techniques if the economic and social consequences of the present system of mining the forests are to be avoided.

152. A number of constraints to the development and management of the forests have emerged and those include institutional, economic and industrial constraints. Within the institutional field there are certain difficulties. Thus, the Agrarian Law states the forest shall be managed in accordance with forest legislation while the law relating to CONDEFOR requires that body to institute agro-silvicultural programmes jointly with INA on forest land although there appears to be no immediate prospect of conducting the soil surveys required in such a programme. Again, no legal provisions exist to ensure the survival of natural or artificial regeneration on privately owned land following harvesting yet much of the 1981-1985 reforestation programme in Las Lajas is scheduled to be undertaken on such land. If the owners fail to cooperate, the future management in LLFMU is in jeopardy.

153. Within the economic and industrial fields, it seems clear that because of highly selective harvesting and low stumpage fees the forest areas are subsidizing the forest industries and some mechanism to integrate the entire forestry sector is urgently needed. Further difficulties arise in obtaining finance for forestry development, e.g. The Comayagua Forest Development Programme. The Government feels unable to undertake the task and international funding requires that activities funded from such sources must be confined to nationally owned lands even although the private lands form an integral part of the forests which should logically be managed as an entity.

154. It seems clear that the concept of multi-use in the pine forests of Honduras is, as in all other forest areas, a highly desirable concept yet one which is most difficult to achieve on any significant scale. Many of the difficulties which are apparent apply elsewhere including the problems of controlling the diverse forest activities of the local population, the establishment of the mutual confidence and trust necessary for the successful operation of a workers cooperative and the problem of satisfying the demands of the forest workers for land on which to grow their crops without introducing the incipient destruction of the forest.

CHAPTER 4

EVALUATION OF MANAGEMENT SYSTEMS

4.1 General

155. From the above outline and discussions of the four case studies of forest management it is clear that the management of areas devoted to the production of tree crops, whether maintained as an intimate mix of indigenous species (and to which the term "natural forest" is loosely applied) or as land devoted to the culture of species established as plantations, is beset by a number of problems arising from the potential multiplicity of uses and the difficulties of identifying the most appropriate alternative for a given situation. Some of these uses are mutually compatible while others are partially or completely incompatible.

156. It is difficult to pair the different uses as strictly compatible or strictly incompatible. Primarily compatibility or otherwise depends upon the intensity of use to which the area is subjected. At low intensities of use, two alternatives could be fully compatible although incompatibility may arise on account of the intensive use for realizing any one of the objectives.

157. In all four countries the following three objectives have been singled out for mention in the respective documents on Forestry Policy. These are:

- i) watershed protection
- ii) wood production to meet industrial or export demand
- iii) the production of non industrial products such as bamboos, canes, fuelwood, resin, thatching material, etc.

It is necessary to examine the extent of achievements in respect of these different objectives and whether conflicts between different uses are being resolved.

4.2 Watershed Protection

158. Being a non-marketed and indirect benefit conferred by the forest any achievement/deficiency of watershed protection cannot be easily quantified. Maintenance of natural forest helps to protect the soil and regulate the water supplies whereas the utilization of forest land for agriculture which involves the clearance of tree growth and the cultivation of annual or seasonal crops may adversely affect the watershed. Such changes in use are seldom based upon land capability studies but rather are dictated by socio-economic pressures. This has been brought out in all four case studies and particularly in the section relating to the savanna areas of Ghana. The occurrence of fire within the watershed areas is a further cause of damage, yet in Kerala, where 70% of the annual expenditure is utilized for timber extraction, only 0.3% is expended on fire protection and this is spent on plantation areas, indicating the low priority assigned to natural forests and the watersheds.

159. Confirmation of the subservient role of watershed protection is frequently shown in the transfers made in successive working plans of areas from the Protection Working Circles to the Selection Working Circles. Selection felling carried out in evergreen forests, it is claimed, causes minimal disturbance to the ecosystem and permits the maintenance of protective values. However, such decisions are generally dictated by commercial considerations once an area becomes accessible and demands are made for the previously inaccessible

timber located on the area. Thus, although watershed protection is listed as a high priority in management it receives scant attention in practice.

4.3 Wood Production to Meet Industrial or Export Demand

160. In relation to wood production the concept of sustained yield is accepted as being the ultimate aim of those sections of working plans dealing with timber production, yet in Ghana a reduction of the felling cycle and the failure to cut over-mature trees of less popular species have led to a more severe creaming of the forest than formerly and the feeling is that over-exploitation of the economic species is taking place. In Trinidad, intensive exploitation of the natural forest is taking place in annual coupes on a felling cycle of thirty years even although regeneration on the heavier soils on which this is being practiced is not yet assured. In Honduras, the first management plan of that country has prescribed an annual coupe some 18% larger than the theoretical annual coupe and even then the yield is expected to be 15% lower than the volume theoretically available. In Kerala, a marginal reduction has taken place in wood production since 1974 although the conversion of protection areas to selection felling areas and the clear-felling of moist deciduous forest has accounted for 80-90% of wood output. The poor regeneration in ever-green forests will also adversely affect production in future years.

161. Policy statements give low priority to revenue benefits but in practice the opposite pertains and plantations are often formed in Kerala with the object of enhancing short-term revenue rather than as a contribution to future wood production. In other words, wood production and short- to medium-term increase of revenue are given priority and if other policy objectives such as long-term productivity, the production of minor forest produce, protection of the environment, etc., are achieved, the results are incidental to and not due to positive management for such benefits.

4.4 The Production of Non-Wood Products

162. As the intensity of management increases in favour of wood production from the natural forest or conversion of the forest to plantations, so the ability of the land to produce the traditional minor products is reduced or eliminated. Extreme cases occur in the study areas and perhaps the most expressive is that of villagers in the savanna areas of Ghana having to use the animal dung for fuel rather than fertilizer because of a shortage of fire-wood.

4.5 Relevance of Management to Multiple-Use

163. The concept of multiple-use is not new having been practiced by traditional societies in all four study areas, deriving food, fodder, fuel, fibre, etc. from the forest. A low man/land ratio permitted a continuity of multiple benefits but as population densities increased so the demands on the forest increased, priority products emerged and management intensified in a direction calculated to satisfy the products demanded. The demand for high quality timber and industrial woods increased with increasing population and the transition of management from protection to selection to conversion (plantation) working circles illustrates the point made. However, multiple-use management does not imply the realization of all conceivable benefits from every unit of forest land and zoning for separate benefits, provided such zones were accessible, would be helpful in most instances. Against this, the trend is towards the production of wood at the cost of other benefits and to the detriment of the poorest sectors of society. In most of the study areas, poverty can be acute and if land use is not also directed to satisfy the needs of this sector, the concept of multiple-use ceases to be socially relevant.

4.6 Conclusions

164. It has been shown from the studies made in Kerala and Ghana that the tropical mixed hardwood forests are not being managed on a sustainable basis, protection forests remain as such only as long as they are inaccessible and investment in regeneration of the natural forest and in fire protection is negligible. A parallel situation occurs in Trinidad where the shelterwood system of management has been phased out and has been replaced by intensive exploitation, controlled by area eventhough there is no indication that adequate regeneration of commercial species will become established as a post-harvesting crop.

165. In the case of plantations, efforts are being directed primarily towards the extension of the area under plantation crops without adequate regard for the suitability of the sites for the species planted. In the case of Ghana, the plantation programme produced only 60% success because of the desire to introduce taungya as a means of satisfying a demand for land from the local population but without the ability to adequately supervise the widely diffuse nature of the plantation scheme. Generally, existing management practices are aimed at wood production and if other benefits accrue they are incidental to the primary object. Thus, none of the countries covered in this study have entirely managed to carry out in practice the concept of multiple-use management although, in a society composed of many groups and classes with diverse demands, multiple-use would seem to be the concept which should, ideally, be the principal object of management. That this is not the case in the four countries studied is a reflection of the two pressures on the forest estate which outweigh all others, viz. the pressures (whether local or national) of high population densities on the forest lands and secondly the pressures to maximize the revenue accruing from the sale of forest products irrespective of the effect of such a policy on the ability of the forest to sustain existing levels of productivity.

CHAPTER 5

FUTURE TRENDS IN MANAGEMENT OF FOREST AREAS

166. It would appear that two alternative trends in the use of land will have profound effects on forest management. The first of these trends will be as follows:

- i) Agricultural productivity will remain static and increased production for increased populations will be obtained by increasing the area under production. Improved accessibility will convert forest land to agricultural crops, especially rubber, cocoa, palm-oil, etc.;
- ii) Perennial crops will be expanded at the expense of seasonal crops, unemployment will increase and the states or countries will import more food grains;
- iii) Unemployed persons will migrate to outlying areas thus reversing existing trends and invasion and destruction of forest reserves will take place;
- iv) Industrial expansion is likely to continue without regard to long-term supplies of forest-based raw material and lead eventually to accelerated deforestation;
- v) With stagnating agricultural and industrial production, governments will accelerate timber production to increase revenue.

Under the above situation, forest management will move increasingly towards single or exclusive uses to the detriment of multiple-use.

167. An alternative solution (proposed in the case of Kerala) is of interest. Under this alternative the following strategy would be adopted.

- i) Land utilized for agriculture will be stabilized at the present area, increased production will come from improving productivity and the present trend towards perennial cash crops will be reversed;
- ii) Manufacturing capacity will be expanded in those sectors not dependent upon agro-forestry-based raw materials and there will be a rationalization of raw material supplies to the wood-based industries;
- iii) Government reliance on forest revenue will be reduced by the improvement in the agricultural and industrial sectors;
- iv) Priority will be given to supplying the forest-based needs of the population.

168. These trends are probably relevant to most countries in the humid tropics; however, they are not entirely relevant to tropical pine areas like those of Honduras. The soils involved are often of too poor quality or physically inadequate for perennial and seasonal crops and the only alternative to tree crops or forest may be cattle grazing. Therefore, possible trends for these areas are more likely to be as follows:

- i) All arable land will be cleared and trees only left where agriculture is impossible. Population pressure will have the effect that even very steep slopes will be under some kind of bush fallow and severe erosion will follow;
- ii) Gradually, the continuous high-grading of the remaining forests will lower their commercial volume to a point where they can be considered unproductive for industrial purposes, the wood industry will slowly disappear and the country will eventually have to rely on imports to satisfy its needs for wood products;
- iii) More cattle will be put to pasture in the open forest, fire will be used to reduce the dry wintergrass and pine regeneration drastically reduced. The end result may be grass-covered mountains with a few scattered pine trees except for some inaccessible areas where pine forests will continue to exist.

169. With a determined effort by governments, an alternative trend could be as follows:

- i) All arable land where sustained agriculture is economically feasible will be cleared for this purpose;
- ii) The remaining forest will be managed for industrial wood as its main end product;
- iii) After initial establishment, suitable areas may be opened sufficiently to allow controlled grazing under the tree crop. Improved pastures will be established here, general cattle management upgraded and the combined management of trees and animals will be more profitable than any of the two uses alone;
- iv) During the last years of the pine rotation, the trees will be intensively worked for resin which will generate additional incomes and employment for the rural population;
- v) Yields of industrial wood from the forest will be increased, and, with better utilization standards, so will export of wood products thus assuring a stable industry and better employment opportunities.

170. To summarize, it appears that because of increasing pressure of population on the forests in all of the study areas with the possible and perhaps temporary exception of oil-rich Trinidad, multiple-use management will have to be introduced at some future time and the following priority areas will be of importance:

- i) The formulation of a policy for forestry which forms part of an integrated policy for agriculture, energy, industry and related sectors. Priorities and inter-relationships affecting competing objectives will be defined with technical information being supplied by the forest manager to the policy-making body;
- ii) The allocation of land to specific uses will be made in accordance with the findings of a land capability survey;
- iii) The zoning of land for mutually exclusive forms of use;
- iv) The evolution of appropriate system of multiple-use. Topics for research in this subject include:

- a) The silviculture and management of important constituents of the mixed hardwood tropical forest and the management of plantations of mixed species,
 - b) Growth and yield studies of the various types of mixed tropical forest,
 - c) Effect of logging methods on regeneration,
 - d) Methods of improving natural regeneration of the mixed tropical forest,
 - e) The technical, social and economic aspects of agro-forestry;
- v) The development of institutions which are sufficiently flexible in their organization to cope with the problems of multiple-use management and the cooperation of such institutions with the local populations in deciding upon measures to meet local needs.

PART II

Case Studies on Intensive Forest Management
- including multiple use - in
Kerala (India), Ghana, Trinidad and Tobago and Honduras
(summaries)

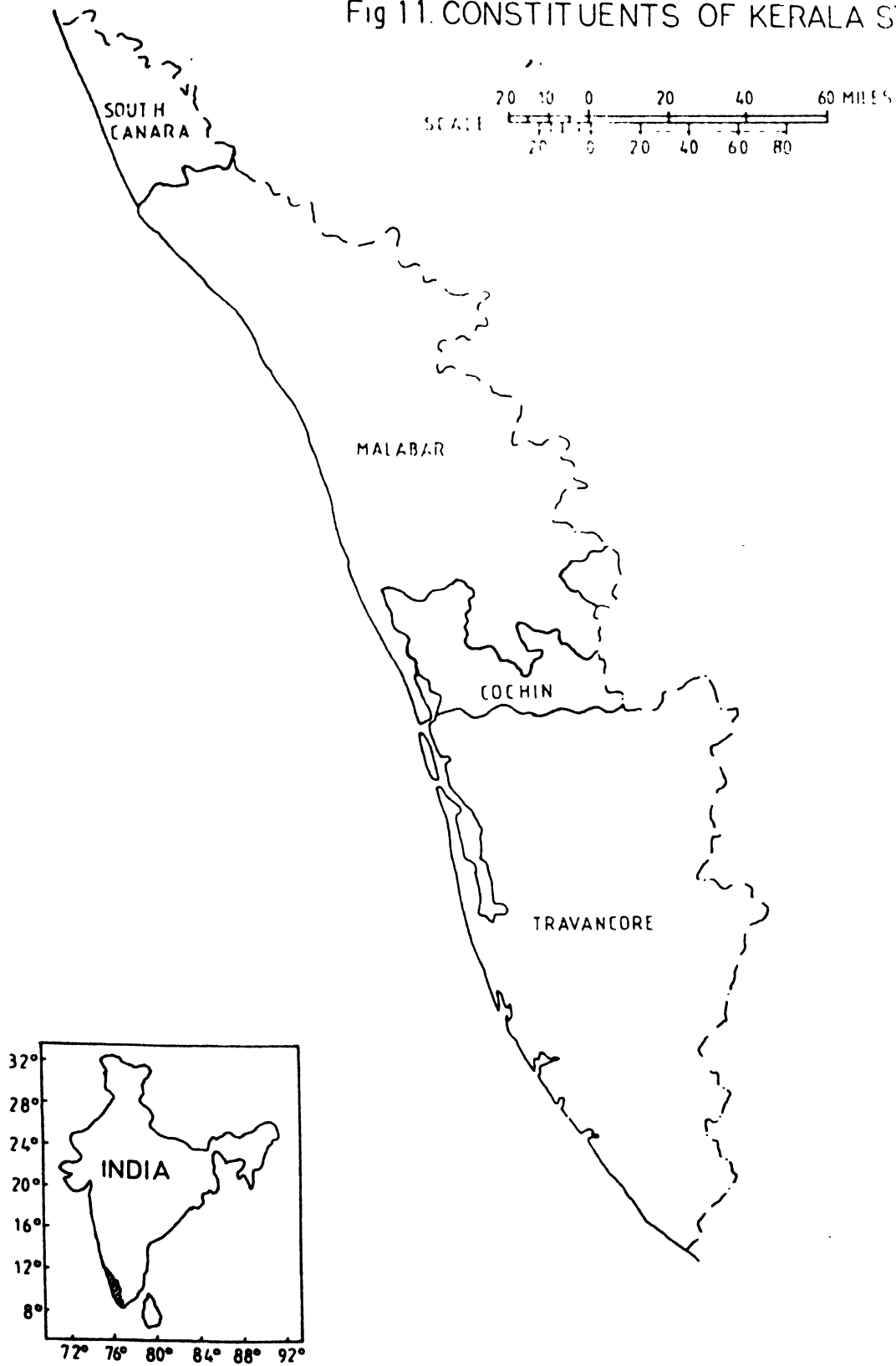
K E R A L A (INDIA)

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Fig 11. CONSTITUENTS OF KERALA STATE



MULTIPLE-USE FOREST MANAGEMENT IN KERALA

1. THE BACKGROUND

1.1 The State of Kerala

1.1.1 Location and Locality Factors

1. Kerala State was formed during the reorganisation of Indian States in 1956 and comprises the erstwhile states of Travancore and Cochin and the Malabar District of the old Madras Presidency. It is situated between latitudes $8^{\circ}17'$ and $12^{\circ}47'N$ and longitudes $74^{\circ}51'$ and $77^{\circ}24'E$, covers $38\,000\text{ km}^2$ and has an equable climate varying from $35^{\circ}C$ in summer to $20^{\circ}C$ in winter. Mean annual rainfall is $3\,000\text{ mm}$ with 80% of this falling in the monsoon period from June to September and the remainder from September to November. Some 10% of the land lies below 7.6 m elevation, 42% lies between 7.6 m and 76 m and the remainder (48%) is higher than 76 m. The coastal low land is densely populated and agricultural and forestry are based mainly in the middle and higher elevations. The total population in 1981 amounted to 25.4 million.

1.1.2 Socio-Economic Conditions

2. Kerala is the most densely populated state in India and in 1981 averaged $654\text{ inhabitants/km}^2$ although in some areas the density exceeded $2\,000/\text{km}^2$. The increase in the state domestic product during the period 1971-81 at 1971 prices was 24% and the per capita income in 1981 was Rs. 1 311.

3. Unemployment among those registering for work was 2.06 million in 1980; huge numbers have not registered at employment exchanges and under-employment due to the seasonal nature of agriculture is rife. Literacy and life expectancy are higher in Kerala than in India as a whole and infant mortality at $42/1\,000$ is less than one-third of the country average. Public investment in health, education, transport and communications has been high and demonstrate that good standards of the physical quality of life can be achieved even in a low income situation.

4. The industrial sector is dominated by traditional agro-based industries and by and large Kerala remains an industrially backward region. The industrial sector employs about 1.08 million workers, 80% of whom work in small-scale and cottage industries.

1.1.3 Land Use Pattern

5. As a result of gradual urbanisation the area under non-agricultural use has increased considerably. Within agriculture, annual and seasonal crops have moved towards a perennial pattern especially the replacement of paddy by coconut. The area under forests has declined although the extent to which this has happened is open to doubt. It has been reported in 1982 that the percentage of the total area under agriculture was 56.1%, that under forest 27.8% and other uses 16.1%.

6. In terms of area and value of production, cash crops dominate the agricultural sector and the State is therefore an importer of food grains especially rice and wheat. Production of important crops, e.g. rice and coconut has declined in recent years and the area under high yielding cereals has fallen and performance has been unsatisfactory. Root wilt of coconut has been the principal cause of lower yields from this crop but effective remedial and preventive measures have yet to be discovered.

1.1.4 Forests and Forestry

7. Depending upon the reporting source, the area of forests in Kerala has been calculated as from 9 400 km² to 11 280 km², i.e. 24.2% to 29.0% of the area of the State. The discrepancy arises from differences in the criteria for defining forests and in respect of the largest of the estimations, these include forest reserve areas which have been diverted to other forms of land use but which have not yet been formally de-reserved. The lowest of the estimates, i.e. 9 400 km² is probably the most accurate. Since 1971 all forests in the State have been in public ownership.

Forest Types

8. The forests fall under the broad category of tropical moist forests and are composed of the following types:

| | |
|---|-----------------------|
| 1. Evergreen and semi-evergreen forests | 4 750 km ² |
| 2. Moist deciduous forests | 2 746 km ² |
| 3. Dry deciduous forests | 170 km ² |
| 4. Montane sub-tropical and temperate forests | 160 km ² |
| 5. Man-made forests | 1 574 km ² |
| Total | 9 400 km ² |

Two types of evergreen forest are recognized, viz. the West Coast Tropical Evergreen and the Southern Hill Top Tropical Evergreen. Exploitation of these forests is limited to commercially important species, e.g. Vateria indica, Dipterocarpus indicus, D. bourdillonii, Dichopsis elliptica, Mesua nagassarium and Calophyllum spp.

9. The West Coast Semi-evergreen Forests occur at a transitional zone between the evergreen and the moist deciduous types and are characterized by a heterogenous mixture of evergreen and deciduous species. Important constituents include Haldinia cordofolia, Anthocephalus chinensis, Calophyllum tomentosum and Toona ciliata. As in the case of the evergreen forests, they are managed under a selection felling system.

10. The Moist Deciduous Forests are closed high forest of some 30 to 35 m height and the dominant species are mainly deciduous. Important species include Tectona grandis, Pterocarpus marsupium, Artocarpus hirsuta and Haldinia cordofolia. Bamboo is another important constituent and management aims at converting these forests to plantations of commercial species.

11. The Dry Deciduous Forests occur in the rain-shadow of the Western Ghats and because of the small area of the type they are not of major economic importance.

12. The Montane Sub-tropical and Montane Temperate Forests, products of the higher elevations of the Western Ghats, are shrinking because of annual fires and invasion by grass. In all accessible areas they have been replaced by plantations.

13. Plantations commenced in 1840 when teak was planted in the Nilambur Valley and remained the principal plantation species until 1960 when eucalypts became important for pulp wood. In 1982 the species distribution was as follows:

| | | |
|---------------|-----------|---------|
| Teak | 76 927 ha | (49.6%) |
| Eucalypts | 38 131 ha | (24.6%) |
| Softwood | 23 827 ha | (15.4%) |
| Other species | 16 277 ha | (10.4%) |

In certain areas of Nilambur, teak has now been planted for a third rotation but indiscriminate planting on less fertile areas has increased the proportion of low quality plantations.

14. Large-scale planting of eucalypts commenced in the 1960's with E. tereticornis and E. grandis being used to plant-up grass-lands but because of the strong demand for pulp wood large areas of moist deciduous and evergreen forests are now converted to these species.

15. In 1970 the total growing stock in Kerala forests was estimated as 185 million m³ but removal of old growth and replacement by plantations has since reduced this amount considerably. The recorded yield of produce for selected years is shown in Table 1 but, particularly in the case of fire-wood, the amounts shown are less than the amounts actually removed.

Table 1
Yield of Timber and Other Produce

| Year | Timber (m ³) | Fire-wood (tons) | Poles (No.) | Charcoal (bags) |
|---------|--------------------------|------------------|-------------|-----------------|
| 1960-61 | 224 560 | 179 383 | 252 349 | Nil |
| 1965-66 | 446 432 | 163 255 | 251 019 | 103 172 |
| 1970-71 | 517 440 | 280 069 | 368 081 | 643 415 |
| 1975-76 | 501 429 | 225 043 | 1 148 969 | 12 522 |
| 1978-79 | 447 495 | 304 683 | 1 387 450 | 151 801 |

Revenue Expenditure and Contribution to State Domestic Product

16. The surplus of revenue over expenditure has increased steadily from 84 million Rs. in 1975-76 to 145 million Rs. in 1981-82, partly as a result of increased out-turn of produce and partly as a result of an increase in the real price of the produce. However, during the same period the contribution of forestry to the state domestic product has steadily declined from 1% to 0.7% indicating that the forestry sector has been lagging behind the rest of the economy.

Wildlife Management

17. Kerala supports a wide diversity of game and avifauna and within the State there are seven wildlife sanctuaries with a total area of 1 822 km². Wildlife management is the principal objective within the sanctuaries but the collection of minor forest produce is permitted. Habitat destruction and poaching are serious problems in all protected areas.

Wood Resources from Non-Forest Areas

18. Agricultural land and plantations are important sources of timber and fire-wood and multiple cropping around homesteads provides a major part of household timber and fire-wood requirements as well as some industrial woods, e.g. matti wood for match manufacture. Species cultivated and used include tamarind, jack, anjili, neem, jamun and bamboo and indications suggest that increasing poverty of small holders has led to the clearance of miscellaneous trees in house compounds either for family use or to augment family income.

Export and Import of Timber

19. Reliable estimates of timber exported to neighbouring states are not available but registers maintained at border check posts suggest that more than 50% of removals from the forests are exported. Export of teak and rosewood in log form has been banned to encourage local processing.

1.1.5 Forest-Based Industries

20. In 1982, there were 1 024 registered sawmills employing some 6 980 persons. Most units operate in rural areas, are small-scale, operate sporadically and are confined to custom sawing. The larger mills are located in trading centres and sawmill output goes mainly to the construction industry with smaller amounts to mining, quarrying, packaging, etc.

21. The 81 plywood units of Kerala account for 18% of Indian production and concentrate on commercial and decorative plywood. There is an acute shortage of veneer logs and imports are made from Karnataka and Andaman Islands.

22. The match industry consisting of 144 registered plants employs some 2 000 workers and produces box veneers and splints which are exported to dipping units in Tamilnadu. The state forests supply only 10% of the 130 000 m³ required annually by the industry and part of the deficit is made up from farm lands and homesteads.

23. Three pulp and paper units produce industrial and writing paper, rayon pulp and newsprint. Initially fibre from bamboo and reeds was used but as supplies declined, eucalypt plantations became the main source.

24. Forest-based and cottage industries manufacture a wide range of items especially in the household sector and include furniture, baskets, wall hangings, etc. and a large number of cooperatives are involved in the reed industry.

1.2 The Study Area

25. The Quilon district of Kerala has been selected to identify the problems relating to forest management, containing as it does, large-scale teak plantations and extensive evergreen forests.

1.2.1 Location and Locality Factors

26. The district lies between 8°45' and 9°27'N latitude and 76°29' and 77°17'E longitude, has an area of 4 743 km² and altitudes ranging from sea level to 1 780 m. Road and rail communications connecting the State and the district with the adjoining State of Tamilnadu pass through the Aryankavu gap in the Western Ghats, a factor which is of considerable significance to the forests and forestry of the region.

27. Of the total area of the Quilon district, 355 km² are situated in lowlands characterized by paddy fields, coconut gardens, etc. 1 412 km² lie in the midland areas of moderately sloping hills and there are 2 975 km² of highlands with rugged terrain carrying the bulk of the forests of Quilon. The main rivers of the study area are the Pamba, the Achenkovil and the Kallada which divide the area into distinct river basins.

28. Average annual rainfall is 2 760 mm obtained from the South-West monsoon between June and August and the North-East monsoon between September and November. The temperature varies from 25°C to 35°C but winter temperatures in the highland areas are much lower.

1.2.2 Population

29. The population of Quilon district is 2.81 million and average density is 608 inhabitant/km². Growth rate in the period 1971 to 1981 averaged 16.35%. Workers account for 24.4% of the population and agricultural labourers constitute 45% of the total work force. Unemployment is high and the average size of agricultural holdings is 0.6 ha so under-employment is common.

1.2.3 Land Use and Industrial Development

30. Agriculture accounts for 43.5% of land use while forests cover 49.8%. Other forms of land use total 6.7%.

31. Although Quilon has been ranked second in the State in relation to the indices measuring industrialisation, the situation is unsatisfactory. The processing of cashew nut accounts for 87% of employment and automobile and general engineering together with the textile trade are also of importance. There are numerous small-scale industrial units and cooperative societies and the Travancore Plywood Industries and the Punalur Paper Mills are the major wood-based industries. There are also numerous small-scale units manufacturing plywood packing cases, matches, handicrafts, etc.

1.2.4 Forests and Forestry

Forest Area

32. The area of forest is estimated to be 1 784 km² although the application of different criteria by different authorities leads to varying areas being accepted. This district is divided into four forest divisions as follows:

| <u>Forest Division</u> | <u>Area (km²)</u> |
|------------------------|------------------------------|
| Ranni | 781 |
| Thenmala | 476 |
| Konni | 303 |
| Punalur | 224 |
| Total | 1 784 |

Forest Types

33. The distribution of the area under different forest types is as follows:

| <u>Forest Type</u> | <u>Area (km²)</u> | <u>Percentage</u> |
|-----------------------|------------------------------|-------------------|
| 1. Evergreen forests | 526 | 29.5 |
| 2. Semi-evergreen | 502 | 28.1 |
| 3. Moist deciduous | 395 | 22.2 |
| 4. Reeds | 60 | 3.3 |
| 5. Grass-land | 3 | 0.2 |
| 6. Forest Plantations | 298 | 16.7 |
| Total | 1 784 | 100.0 |

34. In the evergreen areas the warm wet climate permits continuous growth throughout the year. The soil varies considerably but is derived principally from gneiss and granite and except in the valleys is generally shallow. The species composition is extremely rich and two sub-divisions are recognized viz. low level evergreen forest occurring below 500 m and the high level sub-division which occurs above about 500 m.

35. The semi-evergreen forests occur in the transition zone between the evergreen and the moist deciduous forests. For management purposes the semi-evergreen forests are usually grouped with the evergreen type and allocated to selection or protection working circles.

36. The moist deciduous forest generally occurs in areas with a rainfall of between 1 500 mm and 2 000 mm. Floristically these forests are poorer than the evergreen and semi-evergreen types but they contain many commercial species. Since most accessible areas have been converted to plantations or other uses, existing forests of this type are confined mainly to steep slopes or ridges.

Forest Plantations

37. The species composition of plantation areas is as follows:

| <u>Species</u> | <u>Area (km²)</u> | <u>Percentage of Total</u> |
|-------------------------|------------------------------|----------------------------|
| Teak | 166 | 55.6 |
| Eucalypt | 64 | 21.4 |
| Matchwood ^{1/} | 59 | 19.9 |
| Others | 9 | 3.1 |
| Total | 298 | 100.0 |

38. Up to the 1960's teak was the principal species planted with the fertile alluvial bank of the Achenkovil river providing ideal conditions but with the extension of teak plantations into less suitable sites the proportion of lower quality classes has increased. Quality Class I teak is found on 6.9% of the teak plantation, Class II covers 29.0%,

1/ Several species

Class III, 47.7% and Class IV, 16.4%. Stocking is poor in a number of the plantation areas and this affects the yield, particularly the thinning yield and might also affect the quality of logs obtained during final felling.

39. Eucalypts were first introduced to the study area in 1960, the main species have been E. grandis and E. tereticornis and with the establishment of the Kerala Forest Development Corporation in 1975, plans were made to convert 13 000 ha of moist deciduous forest to eucalypts to provide pulp wood. The plantations are managed on a coppice rotation of 8 years and the annual increment has varied from 5 m³/ha to 35 m³/ha on the best sites. The average yield is much less than expected with incorrect choice of site, faulty management, fire and disease affecting results.

40. Matchwood plantations were commenced to enhance wood supply to the match factories and therefore Bombax ceiba was chosen but the first plantations failed. Success was achieved in the following years and financial encouragement by Central Government ensured continued expansion of the plantations. In spite of the term "softwood plantations" teak accounts for a major proportion of plants in the plantations.

1.2.5 Demands on the Forest

Demands from Local Industries

41. The Travancore Plywood Industries has an installed capacity of 2.8 million m³ (4 mm thickness) and employs 500 workers. Earlier the Thenmala Division was the main supplier but depletion of stocks led to an extension of the wood catchment area and an increased number of species utilized. Currently the mill uses six species and draws supplies from areas up to 150 km distance.

42. The Punalur Paper Mills is the only bamboo reed-based paper mill in the world, it was established in 1890 and it has an installed capacity of 50 000 tons/annum. The growth of other reed-using industries has led to shortages of raw material and only 35% of capacity could be used during the last three years. Eucalypt fibre has been used to supplement supplies and more distant sources of raw materials are now used.

43. There are 80 sawmills and 23 match units in the district and supplies of wood from the forests are insufficient to satisfy the demands made for raw material.

Non-Industrial Demand

44. Except for forests in interior locations, the forest estate comes under great pressure from densely populated villages on the periphery of reserves especially for fire-wood, small timber and green manure. No system exists for making these available legally and as a result unauthorised collection is rampant and even teak plantations are subject to theft.

Regional and National Demand

45. Being more forested than most other districts, large quantities of wood and other products are transported to distant consumer centres both within and without the State. Railway sleepers and good quality teak for railways and defense authorities are also supplied from the study area and a major portion of supplies for the proposed Ernakulam-Alleppey railway will be met from these forests.

46. No estimate is available of encroachments on the forests of the district but in one range of the Ranni Division alone, some 3 000 ha are encroached upon.

1.3 History of Forest Management

1.3.1 Pre-1947 Era

47. In the middle of the 18th Century the East India Company helped the territorial expansion of Travancore and in 1811 the company's representative became Diwan (Prime-Minister). Lands owned by feudal lords and temples were gradually appropriated to the State and taxes levied on the tenants. Cultivators were encouraged to open up forest land (which covered two-thirds of the State) through subsidies and other inducements. Transfer of power from the East India Company to the British Crown in 1858 resulted in opening up forests for the growing of coffee, tea, cardamom, etc. and in 1865 rules for the grant of full ownership to tenants were enacted.

48. In 1816 a Conservator of Forests was appointed to assist in the timber trade carried on by the Company and teak became a government monopoly that year. Later this monopoly included rosewood, anjili, ebony and sandal wood. As time went on contracts for felling and extracting these timbers were awarded and by 1882 all such timbers were worked by the contract system. Revenue from timber increased from Rs. 89 050 in 1872 to Rs. 311 306 in 1892.

Permanent Reservation of Forest Tracts

49. The Indian Forest Act of 1865 contained provisions for constituting permanent forest reserves and in 1878 the legal difference between reserved forests and protected forests was defined. In Travancore forest legislation was enacted in 1887 and the first reserve² constituted that year. Reservation progressed steadily from 780 km² in 1888 to 6 206 km² in 1935.

Plantation Forestry

50. The first trials of teak in plantations in Travancore were laid down in 1865 and although a failure, regular planting of teak commenced from 1867. Until 1892 the opening of plantations was irregular but from 1893-1907 proper thinning and regular tending operations were undertaken. During this phase stump plants replaced seedling planting giving savings in costs and producing more consistent results. At this time trials were also conducted with both exotic and indigenous species of economic value.

51. From 1908 plantation work was characterized by efforts to reduce unit cost and to increase the annual planting rate. Site preparation, previously done by departmental labour, was modified by the outright sale of standing timber to contractors who also burned and prepared the site. Early attempts to introduce the taungya system failed but from 1922 the system became a feature of plantation work. Under taungya the cost of opening 1 hectare of plantation dropped from the previous Rs. 100-125 to almost no cost and the rate of annual planting accelerated.

Working Plans

52. Early working plans had the limited objective of regulating timber extraction and the first comprehensive plan in the study area was drawn up in 1908 but although silvi-cultural principles were evoked, over-exploitation of accessible areas could not be effectively controlled because of insufficient field staff and the reliance on contractors who were paid by the volume produced.

Agriculture-Forestry Conflicts

53. A rapid increase in the conversion of forests to agriculture took place from 1865 when government tenants were given permanent rights in the lands cultivated (paragraph 47 above). Indigenous banking institutions and Government provided finance to help develop agricultural schemes and the rapid development of communications in the second half of the 1800's gave additional impetus to colonisation of the hilly regions. Largely because of population growth traditional agriculture also expanded into adjoining valleys and slopes, permanent agriculture being practiced on the better soils and shifting agriculture on the poorer land. Tapioca provided very high yields on newly cleared forest land and as food supplies became shorter in relation to the increased population, tapioca was widely planted as a rice substitute. Even so, in 1938 it was necessary to import into Travancore almost 300 000 tons of rice at a cost of Rs. 24 million and during World War II, the Government leased cultivable areas within reserves for food production. While population increased at 2% per annum between 1931 and 1951 the increase in cultivable land was only 0.1% per annum. At the same time, almost half of the cultivable land was under non-food crops, e.g. rubber, tea and coffee.

1.3.2 Post-1947 Period

54. Kerala was formed at the time of the India Union in 1949 out of the amalgamation of Travancore-Cochin State with the Malabar District of the old Madras Presidency. The Forest Policy of independent India was proclaimed in 1952 revising the British India Policy of 1894 and the objectives of the new policy are given in Section 2.1.1. Initially, forestry was listed as a state (provincial) subject in the Indian Constitution and state governments were concerned principally with meeting the needs of the agricultural sector and secondly with enhancing government income. Both objectives had a direct impact on forestry in the State.

Conflicts between Agriculture and Forestry

55. The diversion of forest land to agriculture which began in the early 1940's increased momentum in later decades and all encroachments into reserves made prior to 1977 have been legalized. In addition four public sector units cultivating rubber, sugar-cane, tapioca, cashew and oil-palm use lands still classified as forest reserves. Public utility works such as irrigation and hydro-electric projects have encroached on forest reserves and frequently the improved accessibility to such schemes has triggered-off large-scale conversion to agriculture as well as plantation forestry.

Plantation Forestry

56. The major change from the past was the introduction of five-year development plans which superseded working plans by providing investment funds for forest development. Priority given in the 1956-61 Plan to industrial development helped promote the forest-based industries particularly the pulp and paper industry and this in turn caused additional demands which could not be met by the indigenous raw materials hence the commencement of large-scale plantations, especially eucalypts. In 1960 eucalypts plantations accounted for less than 1% of the total forest plantation areas of the State but by 1982 the percentage had risen to 25%.

57. The National Commission on Agriculture (1972) emphasised the need for a departure from traditional conservation-oriented forestry towards an aggressive plantation programme designed to satisfy the projected requirements of the wood-based industries and identified

two constraints hampering implementation. These were shortage of investment funds and institutional impediments in the organisation of the forest department. The solution proposed was the formation of autonomous Forest Development Corporations and such a Corporation was formed in Kerala with the principal objective being the formation of pulp wood plantations.

58. In the pursuit of this objective, the forest wealth was viewed quite differently from the perspective of the National Forest Policy in that forests were to be clear-felled and planted with suitable fast growing species yielding higher return per unit area. It was also pointed out that "Production of industrial wood is the raison d'être for the existence of forests". In addition, and by a constitutional amendment of 1976 the Central Government gained increasing authority over forest management in the states thus giving greater power to central planners to impose conversion of the forests to serve the needs of the forest-based industries.

59. Social forestry was also considered by the National Commission on Agriculture and recommendations made for increased production of fuelwood especially and also small timber and fodder. In Kerala, social forestry is confined to the distribution of seedlings to farmers, etc. and to avenue planting.

General Trends in Forestry

60. Before the constitution of reserves the local population was free to use the forests to satisfy its needs but when revenue from the land became important to governments, farmers were encouraged to convert forests to agriculture. The forest policy of 1894 stressed that forests could be justified only on the basis of indirect benefits to agriculture but by the time the 1952 policy was formulated, the power-base of government had shifted from agriculture to industry and trade and hence the influence of the wood-based industries. The claims of the local communities on the forests were to be subordinated to those of industry but since forestry remained a state matter and since agriculture was important to the State, central government policy directives had little impact at local level. With the passage of the constitutional amendment of 1976 and the Forest (Conservation) Act of 1980 curtailing the state government's powers to de-reserve forests, a further impetus has been given to the industrial orientation of forestry and a continuing trend away from multiple-use forestry is evident.

2. PRESENT FOREST MANAGEMENT

2.1 General Description

2.1.1 The Policy Base

61. None of the states of the country has drawn up a state forest policy and the basis of guidance for forest management is therefore the National Forest Policy of 1952. The Policy identified the following National needs:

1. The allocation of land to the use for which it is most fitted.
2. The protection of water catchment areas, the reduction of soil erosion and the protection against coastal erosion.
3. The provision of tree shelter to improve the environment and promote the well-being of the population.
4. The provision of increasing supplies of grazing, small wood for agriculture and fire-wood.
5. The provision of a sustained supply of timber and other forest produce for defense, communications and industry.
6. The realisation of maximum revenue consistent with the above.

2.1.2 Working Plans and Work Programmes

62. Working plans are drawn up to guide and control those aspects of the Policy which are being implemented within a Working Plan Area. The detailed procedure for the preparation and approval of working plans has been laid down in the Kerala Forest Code and each plan is written in two parts, viz. Part I containing the background information concerning locality factors, characteristics of the vegetation, utilisation of produce, statistics of growth and yield and the results of past management, etc., and Part II which deals with future management, division of the area and prescriptions for all work to be done during the period of the plan (generally ten or fifteen years).

63. Under Five-Year Development Plans, broad sectoral priorities are decided by the Planning Commission, sectoral programmes are drawn up to advance the chosen priorities and state level proposals may be modified to conform to the priorities envisaged at national level. These programmes have an influence on state forest management and most of the matchwood, fuelwood and industrial plantation programmes have been undertaken with specific allocations of subsidies from Central Government. Five-year plan targets seldom consider local conditions but since funds are made available on the basis of programmes of the five-year plans, working plan prescriptions are frequently subordinated to the five-year programmes.

64. An annual plan of operation is drawn up for each Division by the divisional officer incorporating operations arising from both working plans and five-year programmes. The annual plan may have to be modified according to the Departmental budget available but once approved the plan may be implemented.

2.1.3 Forest Administration

65. The Forest Department is the main arm of the Government which implements the policies and programmes and is organised to permit the performance of such specialised aspects of

forestry as research, planning, wildlife, social forestry, etc. as well as providing a chain of command from the Head of Department down to forest officers in territorial ranges.

66. The Kerala Forest Development Corporation is another agency involved in forestry and was established with the object of promoting the supply of raw material to forest-based industries (paragraph 57). All policy decisions are made by a government nominated board of directors and the senior posts are manned by officials on secondment from the Forest Department.

2.1.4 The Legal Framework

67. The legal framework within which the forests are managed is as follows:

- (i) The Kerala Forest Act, 1961, deals with the constitution of forest reserves, the duties and responsibilities of officials functioning under the Act, defines forest offences, lays down penalties for infringements and sets out procedures for bringing offenders to court, etc. Rules made under the Act regulate the transport of forest produce.
- (ii) Kerala Forest (Vesting and Assignment) Act, 1971, by which the government took over the private forests without paying any compensation. It also stipulates the assignment of part of the forests suitable for agriculture to the landless.
- (iii) The Cattle Trespass Act, 1971, defines the procedure for dealing with cattle trespassing in forest areas closed to grazing.
- (iv) The Wildlife Protection Act, 1972, prescribes rules relating to the hunting of wild animals and provides for the proclamation of national parks, game reserves and closed areas.
- (v) The Kerala Forest Produce (Fixation of Selling Price) Act, 1978, regulates the price paid to the forest department for industrial wood supplies to such industries as pulp and paper, plywood and matches.
- (vi) The Forest (Conservation) Act, 1980, stipulates that no state government shall de-reserve any forest reserve without the prior consent of the Central Government.

2.2 Management of Evergreen Forests

2.2.1 Area, Objectives of Management and Organisation

68. The evergreen and semi-evergreen forests cover an area of about 1 030 km² or 56% of Quilon and Management aims to achieve the following:

- (i) Protect steep slopes and catchment areas and to regulate water supplies.
- (ii) Provide timber for industry and other consumers by harvesting over-mature and mature trees without adversely affecting the character of the vegetation.
- (iii) Provide minor forest produce.
- (iv) Improve the stocking of commercially valuable species.

To attain these objectives the evergreen forest has been divided into two working circles (areas under one silvicultural system and one set of working plan prescriptions) viz. the protection working circle and the selection working circle (in areas where accessibility, topography, soil conditions, etc. are suitable substantial areas have been allotted to a conversion working circle, clear-felled and converted to plantations). Easily accessible areas are allotted to the selection working circle for wood production. Not unusually, evergreen forests have been allotted to conversion working circle and clear-felled and planted with species such as teak and eucalypt. In theory, protection working circle should comprise all areas which should be protected so as to maintain their watershed values or other benefits. However, in practice it consists of inaccessible areas which have not been included in any other working circle. When two objectives are compatible, working circles may overlap as in the case of working circles dealing with the collection of minor forest produce. Thus, in the Quilon area there are 1 784 km² of forests; the Rattan Working Circle and the Minor Forest Produce Working Circle each cover the whole of this area and incorporate the Protection Working Circle (898 km²), the Selection Working Circle (655 km²) and the Reed Working Circle which covers all reed-bearing areas.

2.2.2 Management for Wood Production (Selection Working Circle)

69. The objectives within this working circle are to harvest mature and over-mature trees of commercial value, to augment natural regeneration where it is sparse or absent and to maintain the protective function of the forest. Trees harvested are selected on the basis of minimum girth limits and marketability. For organisational convenience, the working circle in Quilon has been divided into seventeen felling series and the yield determination is done separately for each felling series.

Timber Harvesting

70. The harvesting of timber on a sustained yield basis from a natural stand requires that the yield should be regulated to prevent over-cutting. Conceptually, harvesting is linked to the idea of a rotational age but when trees are harvested as they become mature, (e.g. in a polycyclic system in which the area is cut over at periodic intervals to harvest trees which have reached maturity since the previous harvesting) the rotation age has little relevance in deciding the time to harvest.

71. The period of the felling cycle is generally determined by the time taken by the pre-exploitable classes to reach the exploitable girth set for each class of marketable species although where there are many over-mature trees the period may be shortened. In the study area the cycle has been prescribed as 15 years and the area cut over annually in each felling series (the annual coupe) is calculated by dividing the area of the felling series by the period of the cycle.

72. In fixing the minimum girth below which trees may not be exploited, market demands were important but as demands for raw material increased there has been a downward revision of girth limits. Further precautions are exercised in the number of trees which may be removed from unit area and although methods exist which depend upon detailed knowledge of growth rates, mortality, etc. (e.g. Smythie's Safeguarding Formula) the number is generally fixed arbitrarily and varies between eight and twenty per hectare. Current views tend towards increasing range of species which are becoming marketable.

73. Rules have been laid-down for selection felling and these prescribe that no tree within a radius of 20 metres from a marked tree should be felled, marking should be restricted to sound trees, felling should progress systematically through a coupe, and that felling practices should aim at obtaining maximum output with least damage to the crop.

74. In practice the number of marked trees felled and the species composition of the harvest from any one coupe is strongly influenced by the market which the contractor is to supply. Thus although working plans recommend spreading the removal between the various species the preferences of a single user is reflected in the species composition of the harvest.

75. Two administrative systems control the felling, payment and removal of logs. In the case of large industrial users, marked trees are felled by the user, logs are measured before leaving the forest and rates fixed under the Kerala Forest Produce Act. Where small-scale industrial users cannot fell, extract and transport under this system contractors are engaged to fell and transport the produce to government depots and the user then purchases his requirements from the depot. Since 1975 separate contracts for salvaging damaged timber, lop and top, etc. from annual coupes have been awarded after the main contractor has completed operations.

Regeneration Operations

76. Natural restocking after selection felling is inhibited by the absence of adequate regeneration of commercial species, heavy damage to poles and saplings during felling operations and invasion of openings by colonising species, grass and sometimes reeds. In past years prescriptions have been made for clearing undergrowth and dibbling in seeds of commercial species, patch weeding and the removal of unwanted growth, the collection of seedlings from adjoining areas and planting in selected sites and the planting and continued maintenance of nursery raised seedlings of desirable species. Such prescriptions have seldom been implemented.

77. Currently an 'Intensification of Management' scheme is being applied over 40-50 ha of exploited forest under which weed growth is cleared, unwanted trees are girdled and seedlings planted at 2.5 m x 2.5 m. Deficiencies in the scheme include restriction of treatment to the first three years, failure to adjust the light reaching the seedlings by manipulation of the canopy density and restriction of the areas treated to a small fraction of the area exploited. In the Ranni Division, out of a total area of 4 925 ha exploited between 1975 and 1981, only 90 ha were subject to regeneration operations. Success depends not only on adequate financial provision but supervision is also a crucial factor. The cost of the operation for the three-year period has averaged Rs. 1 475/ha.

78. Viewed objectively, the selection system practised in the evergreen forests amounts to nothing more than the selective removal of commercial species having an immediate demand or, in other words, an extensive system of mining timber which takes no account of attaining a normal forest with supportive regeneration of the commercial species.

2.2.3 Management for Non-Wood Products

79. Non-wood products, referred to collectively as minor forest produce include firewood, honey, wax, cardamom, rattan and reeds, etc. When any one of the products becomes commercially important its management is dealt with separately by constituting a working circle for the product, e.g. the management of reeds for the pulp and paper industry under the Reed Working Circle. Working plans do not generally contain prescriptions for augmenting the supplies of minor forest produce and consequently the full potential of the products is not being realised.

80. Cardamom (Elettaria cardamomum) occurs naturally in the undergrowth of the evergreen forests of the Western Ghats and has been widely cultivated since 1869. During 1969-1973 the forest department raised 145 ha and in 1976 the Kerala Forest Development Corporation initiated a planting project which, together with the forest department plantation,

now extends to 1 625 ha. Viewed as a means of improving the productivity of the ever-green forest, the species thrives only under the optimal conditions of light. Long-term viability of cardamom cultivation depends upon favourable world prices and maintenance of the appropriate micro-climate while the necessary weeding and cultural operations preclude the establishment of regeneration of commercial timbers.

81. The evergreen and semi-evergreen forests contain two species of reeds, Ochlandra travancorica and O. scriptoria which are important for the traditional reed-weaving industries and for the modern pulp and paper industry. The Reed Working Circle overlaps the other working circles and is sub-divided into felling series worked on a four-year felling cycle. Cutting rules have been evolved to protect the culms from over-cutting but enforcement is almost impossible over wide areas. Gregarious flowering takes place at about the 7th year after which the clump dies. Complete reliance is placed on natural regeneration for continued supplies.

82. The forests contain a large number of Calamus (cane) species which are important in furniture manufacture. The Rattan Working Circle overlaps all other circles and felling series are worked on a four-year felling cycle. Because of the scattered nature of the growth, supervision is difficult and felling rules impossible to impose throughout the area. No attempt is made to regenerate the canes artificially.

2.2.4 Discussion and Conclusions

83. Management of the evergreen forests is beset by many problems arising from the multiplicity of uses, the identification of appropriate alternatives for a given situation and the compatibility of some uses and the incompatibility of others. Generally at low intensities of use, two alternatives could be fully compatible but become incompatible at a higher intensity of use.

84. Watershed protection is particularly sensitive to the intensity of wood production within the catchment area and especially when evergreen forests are converted to plantations. The problem is to some extent overcome by zoning the most critical areas within a protection working circle and restricting wood production to a selection working circle. However, economic pressure for increasing supplies of timber frequently causes a downward revision of the area under protection by transfer to selection working and the protective function is thereby diminished.

85. Until the beginning of the century many forest areas were unworked because of inaccessibility but as communications improved dramatic changes in the forest took place. As an example of this change the earlier teak plantations in the Thenmala Division were established as a result of access to the Aryankavu valley when the Quilon-Shencottah railway was built. Although there is a general management trend, because of economic pressure, from protection to selection to conversion systems, the reverse may occasionally take place where forest, worked under the selection system, is found to be unsuitable for any sustainable use and then becomes classed as protection forest.

86. The compatibility of wood production and that of minor forest products again depend upon the intensity with which any one constituent of the forest is worked and in the case of cardamom production it has been shown (paragraph 80) that the long-term prospects of wood production have been entirely subjugated to the production of cardamom.

87. Recreational and wilderness uses of the forest in Quilon are negligible but the effect of concentrated use is seen at Plappilly and Pamba where camping facilities for

passing, millions who number some 5 million per year coupled with resultant fires have damaged the productive value of the forests.

88. Management for sustained yield implies establishing a normal forest and harvesting should therefore be confined to the equivalent of the increment. At the same time regeneration sufficient to secure the future crop must be established. But the present selection system is oriented towards mining existing forests to meet the timber demands of industry (paragraph 78) and regeneration has been almost wholly neglected. The availability of additional funds and staff are indispensable if successful regeneration is to be obtained but it seems unlikely that such investment will be forthcoming. The sustainability of the selection system is therefore in grave doubt.

89. Assuming the areas under selection felling remain constant it appears that at each successive felling the yield will diminish and the structure and composition will be so altered that yield will fall to practically nil. Alternatively the selection areas will progressively be converted to plantations and as accessibility to forest areas increases, the protection forests will be restricted to ridge tops and sites otherwise unsuitable for plantation forestry.

90. Ever-present, of course, is the threat to all forest land from agriculture and other non-forestry uses and population growth will aggravate the position. Short-term economic compulsion will influence the utilisation of the evergreen forests and the trend is towards intensive single-use management and away from management for multiple use.

2.3 Management of Moist Deciduous Forests and Teak Plantations

2.3.1 Management Objectives and Organisation

91. The principal objectives of management are the conversion of these forests to plantations of more valuable species and to obtain the maximum revenue consistent with forestry principles. The preferred plantation species is teak because of its value and suitability for a wide range of uses, because of its freedom from serious problems related to disease or pests and because establishment and maintenance techniques are simple and investment requirements low.

92. Working plans sometimes identify two main working circles, viz. the plantation working circle which includes all areas already converted to plantation and the conversion working circle composed of those areas yet to be converted. Occasionally both areas are considered together and named either the conversion or the plantation working circle. Residual areas not included in either working circle because of unsuitability for conversion are generally allocated to the protection working circle.

2.3.2 Management of Teak Plantations

Establishment

93. Conversion to teak plantations is effected by clear-felling the existing forest and planting teak. The rotation is generally fixed at either 60 or 70 years and the annual area to be planted arrived at by dividing the total plantable area by the number of years in the rotation. This theoretical "annual coupe" which would eventually produce theoretically equal annual yields is seldom attained and the preponderance of younger age classes in existing plantations reflects a progressive expansion in the annual rate of planting especially during the 1960's and 1970's when improved access provided much larger areas suitable for conversion.

94. Preparation for planting commences with the marking of all valuable species above 120 cm girth some two years prior to planting, the felling of these trees by contractors appointed by the forest department and the removal of logs together with fire-wood to the departmental timber depots where sales take place. In the second phase all residual tree growth and lop and top down to 30 cm girth at the small end is removed after auction, the slash distributed over the area and the area completely burned before handing back to the department. On well stocked areas some 80 m³ of timber and 120 m³ of fire-wood is obtained but this falls to about 40 m³ and 80 m³ respectively on poorer sites.

95. Nursery site preparation involves the formation of raised beds 15 m x 1 m, dug to a depth of 30 cm and supported along the sides by split bamboo and stakes. Seed sowing is dictated by the pre-monsoon showers of April-May; no pre-treatment is carried out in Kerala and germination takes place in about two weeks. The germination percentage varies between 60% and 80% and one bed is sufficient to provide plants for 0.5 ha. Stumps consisting of 2-3 cm of shoot and 15-20 cm of tap root are cut at planting time, i.e. one year after sowing.

96. After burning of the coupe (paragraph 94) the planting spots are marked out at 2 m x 2 m and after the onset of the pre-monsoon showers in May the stumps are planted by opening a hole with a crowbar and firming in the stumps.

97. Immediately after planting the area is leased out in blocks of about 8 ha to co-operatives or individuals prepared to undertake taungya, i.e. the cultivation for a limited period of agricultural crops and the simultaneous maintenance of the teak. Rules relating to weeding, tending, fire protection, the crops which may be grown, etc. are laid down in the contract and the rental for the lease fixed. Where taungya is not possible, three weedings are carried out in each of the first two years and two in the third year. Total establishment cost including weeding to year 3 is without taungya Rs. 2 870/ha whereas the cost with taungya is Rs. 1 270/ha; when the revenue from rental is taken into account the cost is almost eliminated when taungya is employed.

Thinnings

98. Generally after the third year the teak has out-grown weed growth and thinning commences at the 4th year and is continued at the 8th, 13th, 20th and 44th years. The first two thinnings are systematic or mechanical and reduce the crop to 1 250/ha at first thinning and 625/ha at the second.

99. All subsequent thinnings are selective and aim at producing an even distribution of the crop, the retention of healthy dominant trees and the removal of all dead or suppressed trees and the felling or pollarding of inferior species interfering with the teak. Branches infected by mistletoe (Dendrophthoe falcata) have to be removed and burned. Thinning is carried out with reference to the All India Yield Tables and the general rule of thumb is that in the early stages of a plantation the spacing should be about 1/3 of the average height.

100. Thinning yields obtained from plantations in the Konni Division were as follows:

Yield (m³/ha)

| <u>Age</u> | <u>Poles</u> | <u>Timber</u> | <u>Total volume</u> |
|------------|--------------|---------------|---------------------|
| 4 | 0.439 | - | 0.439 |
| 8 | 2.646 | - | 2.646 |
| 13 | 4.381 | 0.005 | 4.386 |
| 20 | 6.865 | 0.180 | 7.045 |
| 30 | 7.328 | 1.591 | 8.919 |
| 44 | 7.808 | 4.610 | 12.418 |
| | | | |
| Total | 29.467 | 6.386 | 35.853 |

Final Felling

101. In all divisions of Quilon except Thenmala the rotation adopted is 70 years and is aimed at obtaining trees of over 180 cm girth (57 cm dbh) although it is only in quality Class I that the maximum number of trees of this size is obtained. Table 2 illustrates this point.

Table 2

Crop Diameter (cm) and Percentage of Trees
Above the Exploitable Diameter of 57.3 cm

| <u>Age</u> | <u>Site Quality</u> | | | |
|------------|---------------------|-----------|------------|-----------|
| | <u>I</u> | <u>II</u> | <u>III</u> | <u>IV</u> |
| 50 | 55.4 (36) | 39.9 (2) | 26.4 (0) | 17.0 (0) |
| 60 | 60.7 (59) | 45.0 (4) | 30.0 (0) | 19.0 (0) |
| 70 | 65.3 (80) | 49.3 (8) | 33.3 (0) | 20.8 (0) |
| 80 | 69.8 (88) | 53.8 (25) | 36.8 (0) | 22.9 (0) |

Figures in parentheses represent the percentage of stems above exploitable diameter

Source: FRI and Colleges (1970)

102. Based on total volume the rotation of maximum volume production varies from 5 to 15 years depending on site quality. Taking stem wood volume (saw-logs) alone the mean annual increment culminates at age 50 years on Class I sites and age 75 years on Class II sites. Thus, when the 70-year rotation was fixed the demand was for large size timber and poles were of little value. The situation has changed and poles and small timber earn substantial revenue and Thenmala Division has already reduced the rotation to 60 years and further reduction is possible. The average yield from final fellings in the Konni Division amounts to 88.68 m³/ha of timber and 47.79 m³/ha of billets.

Yield and Volume Increment

103. The total yield actually obtained from thinnings and final fellings in the Konni Division averages 172.32 m³ on a rotation of 70 years which gives a mean annual volume yield of 2.46 m³/ha. The total yield and MAI shown in the All India Yield Tables for site qualities I to IV are:

| <u>Site quality</u> | <u>Total volume</u> | <u>MAI (m³/ha)</u> |
|---------------------|---------------------|-------------------------------|
| I | 610 | 8.7 |
| II | 450 | 6.4 |
| III | 293 | 4.2 |
| IV | 141 | 2.0 |

When the yields from the Konni plantations are compared with the All India Tables they generally fall below Class III. The low total yield is primarily due to a low out-turn of thinnings suggesting poor stocking during the establishment phase. When the yield from final fellings alone is considered the out-turn approaches Class III quality.

Economics of Teak Plantations

104. The costs involved in raising teak plantations are given in paragraph 97 and the opportunity cost, which presents particular difficulty in the case of land reserved for forests, is taken here to be the current rental at which the forest department leases land to other agencies, i.e. Rs. 650/ha. The out-turn of thinnings and final fellings has been given in paragraphs 100 and 102 and net income from these at 1982 prices are given in Table 3.

Table 3
Costs and Income from Teak Plantations
(Rs./ha)

| <u>Year</u> | <u>Cost^{1/}</u> | <u>Income</u> | <u>Net Income</u> |
|-------------|--------------------------|---------------|-------------------|
| 4 | 150 | 256 | 106 |
| 8 | 300 | 2 610 | 2 310 |
| 13 | 650 | 4 820 | 4 170 |
| 20 | 1 000 | 8 940 | 7 940 |
| 30 | 1 400 | 13 280 | 11 880 |
| 44 | 1 600 | 26 320 | 24 720 |
| 70 | 12 450 | 317 300 | 304 850 |

^{1/} This includes the costs of felling and conversion into logs, poles and billets

105. Net present value (NPV) on the basis of costs and benefits at a discount rate of 5% is given in Table 4.

Table 4
Net Present Value of Teak Plantations
(Rs./ha)

| Alternative | Cost | Benefit | NPV |
|-----------------|--------|---------|-------|
| Without taungya | 15 686 | 22 447 | 6 761 |
| With taungya | 14 124 | 23 447 | 9 323 |

Even without taungya a teak plantation yields a high present value.

106. A social cost-benefit analysis of conversion of moist deciduous forest to teak plantations involves a number of factors which are almost impossible to quantify with exactitude and is therefore not attempted here.

2.3.3 Matchwood Plantations

107. The important matchwood species raised in plantations in the study area are Bombax ceiba, Ailanthus triphysa and Euodia luna-anukenda; the total area covers 5 714 ha.

Management Practices

108. The softwoods are either raised in intimate mixture with teak in which case the teak and softwood are spaced at 2.5 m x 2.5 m or as a pure crop spaced at 4 m x 4 m. Weeding is carried out as for teak and thinnings made at the 8th and 13th years. The rotation will vary from 30-40 years and it is expected that the crop will reach 150 cm (48 cm dbh) girth in this time. Yield tables are not available.

109. The performance of Bombax has been unsatisfactory largely because of different growth characteristics from the teak with which it is planted. Ailanthus is now planted extensively by the Kerala Forest Development Corporation and is a useful species for farm lands and homesteads.

2.3.4 Multiple Use of Natural Forests vs. Teak Plantations

110. The volume and variety of minor forest products is severely restricted under monocultures e.g. teak and the altered habitat and availability of food adversely affect wildlife. During the formation period of plantations run-off and hence erosion is accelerated but the later effects on stream-flow have not been quantified.

111. Currently the multiple use of teak plantations is limited to the cultivation of food crops under the taungya system in younger plantations. The costs involved to taungya farmers (rent, labour and materials) amount to Rs. 3 400 and Rs. 2 400/ha in the 1st and 2nd years respectively while the income at farm gate prices in those years is Rs. 6 000 and Rs. 4 800 i.e. profits of Rs. 2 600/ha and Rs. 2 400/ha respectively. Indications

suggest that taungya, especially with tapioca, have deleterious effects on the site but these have not been quantified and taungya with tapioca is likely to continue in Kerala.

112. To improve the productivity of land under teak a 5-year scheme was commenced in 1976-1977 which envisaged the planting of pepper, cocoa and medicinal plants in plantations in which the final thinning had been done. By 1982, 287 ha had been established in three of the divisions. The expected internal rate of return of 15% has not been realised and the annual income/ha falls very far short of that expected.

113. Apart from a deciduous species like teak being unsuitable as shade tree for cocoa, it is clear from results by small farmers from intercropping that their success is due to the personal attention given to all cultural operations and that this cannot be achieved under institutional control. Due to unsatisfactory results the programme is now shelved.

2.3.5 Treatment of Unconverted Areas

114. As in the evergreen and semi-evergreen forests, areas of moist deciduous forest which are inaccessible or in which the terrain is difficult are grouped in the protection working circle but as accessibility improves there is a tendency to convert to teak. Future management will depend upon a number of factors, particularly population pressure, demand for wood products and government's attitude to revenue derived from the forestry sector. Thus, the treatment of the remaining unconverted forests is not a technical question but is clearly a matter to be decided at policy (i.e. governmental) level and in the absence of a clear directive of policy short-term options will tend to be favoured even if these compromise long-term benefits.

115. In the conversion of natural forests to plantations, several other indigenous species and the exotic, Eucalyptus, are alternatives to teak. No attempts have yet been made to evaluate the economic, social and environmental costs of such conversions although plantations of eucalypts have been formed on a large-scale (paragraph 39).

3. CRITICAL EVALUATION OF PRESENT FOREST MANAGEMENT

3.1 Attainment of Policy Objectives

116. The policy under which management has operated has been outlined in paragraph 61 and an attempt should now be made to evaluate how successfully the policy has been applied.

117. Watershed management features prominently in the policy but success or failure is difficult to quantify. Conversion from natural forest to agriculture although affecting catchments have been dictated by socio-political pressures and not by land capability studies. The destructive capacity of fires within catchments is obvious yet only 0.3% of expenditure goes on fire protection while selective logging is dictated by commercial concern and not by consideration for the protection of the catchment area. In practice, watershed management receives low priority although listed as a high priority objective.

118. Wood production increased during the years 1957 to 1974 and thereafter a marginal reduction has taken place. Selection felling of evergreen forests and clear-felling of moist deciduous forests have accounted for 80 to 90 percent of wood output and the poor regeneration in evergreen forests will affect future production. Present out-turn is aimed at the regional and national market and benefits to the local population are scant. Long-term output will depend on the area retained as forests and the success achieved in regeneration of the forests. The former depends upon socio-political factors and the latter on institutional, technical and financial inputs.

119. Policy statements give low priority to revenue benefits but in practice the opposite pertains and plantations are often formed not as a contribution to future wood production but with the object of enhancing short-term revenue. In other words, wood production and increase of revenue are given priority and if other policy objectives such as the production of minor forest produce, the protection of the environment, etc., are achieved, the achievement is incidental and not due to positive management for such benefits.

120. An important constraint on effective forest management is the national forest policy of 1952 which is frequently used as a facade to pursue objectives diametrically opposed to those prescribed. A forest policy should be closely linked to other sectoral policies especially agriculture, industry energy, etc. These, however, have no clear-cut policies and lack of an agricultural policy, for example, has been responsible for most of the encroachment and alienation of land for plantations of rubber, oil-palm, etc. Industries are established without assurance of long-term availability of raw materials and once commenced, political and economic interests ensure that raw material is made available whatever the social cost.

121. Institutional constraints on forest management arise from the inflexibility of the vertical structure of the forest department which inhibits its ability to respond to change. Originally set-up to administer and police the forest estate and organise timber extraction, it appears incapable of adapting or responding to the need to protect watersheds, the maintenance of forest gene pools, recreational and wilderness values, the satisfying of rural needs, etc. New sections created to handle social forestry, wildlife management, etc. are staffed by promotion based on seniority and not by those specifically trained for the purpose. Although these shortcomings have been recognized by government the only response has been the creation of another institution namely the Forest Development Corporation.

122. The shortage of field staff at all levels is another important constraint on management and this is reflected in the lack of supervision of work connected with regeneration,

tending, weeding, thinning, harvesting, etc. In addition, evaluation of the execution and results of the various programmes in relation to the objectives of these programmes is ignored and assessment is concerned primarily with whether or not existing rules and regulations are being observed.

3.2 Technical and Financial Constraints on Management

123. For successful management an adequate knowledge of the resource base, area, vegetational types, all factors of the locality, increment, land capability, etc. are a prerequisite. Although management has had a long history, such information is not readily available. The most important restraints are inadequate knowledge of forest dynamics and ineffective methods of regenerating the evergreen forest. Site selection for plantations is based on personal judgement and not on objective assessment of locality factors and plantation failures result. Research, education and training are poorly financed and in-service courses to up-date initial training are either insufficient or not available.

124. All of the foregoing deficiencies of, and constraints upon management are compounded by financial constraints arising from the existing system of allocating funds from the general governmental budget. Such funds are allocated on an annual basis and therefore give no assurance of the continuing support so necessary in the case of long-term forestry and this was an important consideration in setting up the Forest Development Corporations.

3.3 Relevance of Management for Multiple Use

125. The concept of multiple use is not new having been practiced by traditional societies which derived food, fodder, fuel, fibre, etc. from the forest. A low man/land ratio permitted a continuity of multiple benefits but as population density increases the demands on the forest increase, priority products emerge and management intensifies in a direction calculated to satisfy the demand for specific products. In the study area the demand for high quality timber and industrial woods has increased with the rise in population and the transition of management from protection to selection to conversion working circles illustrates the point made. However, multiple-use management does not imply the realisation of all conceivable benefits from every unit of forest land and zoning for separate benefits, provided such zones were accessible, would be sufficient in most instances. Against this, the trend in Quilon is towards uses which enhance wood production at the cost of other benefits to the detriment of the poorest sectors of society. In a country where poverty is acute, if land use is not directed to satisfy the needs of the poorest the concept of multiple use ceases to be socially relevant.

4. FUTURE TRENDS IN FOREST MANAGEMENT

126. It has been shown that the evergreen forests are not being managed on a sustainable basis, protection forests remain as such only as long as they are inaccessible and investment in regeneration of the natural forest and in fire protection is negligible. In the case of teak plantations, efforts have been directed primarily towards extending the area under teak, the confinement of teak to suitable site qualities has been neglected and post-planting cultural operations have been inadequate. Existing management practices are mostly aimed at wood production and if other benefits accrue they are incidental to the main objective. This being the trend, it is questionable if multiple-use management has any future although, in a society composed of many groups and classes with diverse demands multiple use seems to be the only rational option.

127. The high population density and chronic unemployment are important factors which will influence land use planning in Kerala. Based upon what may happen in the agricultural and industrial sectors two extreme but probable situations are described below.

4.1 Continuation of the Present Trend in Forest Land Use

128. In the first situation the main features will be:

- (i) Agricultural productivity will remain static and increased production will be obtained by increasing the area under production. Improved accessibility will convert forest land to agricultural crops especially rubber, cocoa, oil-palm, etc.
- (ii) The area of perennial cash crops will be expanded at the expense of seasonal crops, unemployment will increase as a result and the State will import more food grains.
- (iii) Changing agricultural patterns in the lowlands will lead to a migration of unemployed to the highlands with consequent encroachment and destruction of forest reserves.
- (iv) Industrial expansion may continue without regard to long-term supplies of forest-based raw material and lead eventually to accelerated deforestation or privatisation of forest tracts.
- (v) With stagnating agricultural and industrial production, government will accelerate timber exploitation to balance revenue.

Under the above situation forest management will move increasingly towards single or exclusive uses to the detriment of multiple use.

4.2 The Alternative Solution

129. The important features of this situation are as follows:

- (i) Land utilised for agriculture will be stabilized at the present area, increased production will come from improving productivity and the present trend towards perennial cash crops will be reversed.
- (ii) Manufacturing capacity will be expanded in those sectors not dependent upon agro-forestry-based raw materials and raw material supply to wood-based industries will be rationalized.

- (iii) Overall improvement in the agricultural and industrial sectors will reduce governments reliance on revenue from the forests.
- (iv) Priority will be given to supplying the forest-based needs of the population.

4.3 Future Action

130. Because of the high population pressure and diversity of demand, multiple-use management will have to be introduced at some future time and the following priority areas will be of importance:

- (i) The formulation of a policy for forestry which forms part of an integrated policy for agriculture, energy, industry and related sectors. Priorities and inter-relationships affecting competing objectives will be defined with technical information being supplied by the forest manager.
- (ii) The allocation of land to specific uses will be made in accordance with the findings of a land capability survey.
- (iii) The zoning of land use for mutually exclusive forms of use.
- (iv) The evolution of appropriate systems of multiple use.

Topics for research in this subject include:

- a) The silviculture and management of important constituents of the evergreen forests and the management of plantations of mixed species;
- b) Growth and yield studies of evergreen forests;
- c) Effect of logging methods on regeneration;
- d) Methods of improving regeneration in the evergreen forests;
- e) The technical, social and economic aspects of agro-forestry;
- (v) The development of institutions which are sufficiently flexible in their organisation to cope with the problems of multiple-use management and the cooperation of such institutions with the local populations in deciding upon measures to meet local needs.

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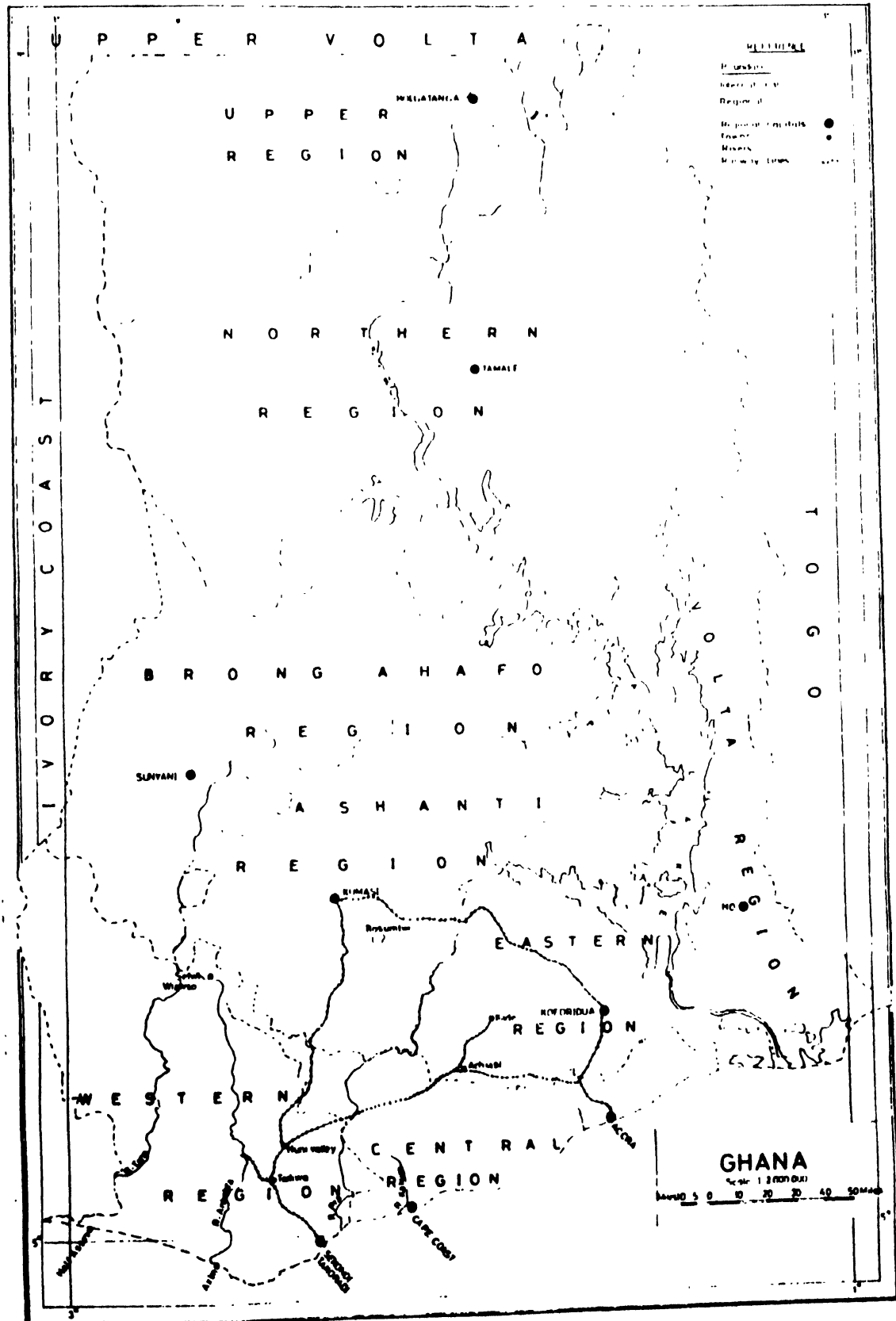
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MAP 1

ADMINISTRATIVE



1. THE BACKGROUND

1.1 General Description of the Country

1. Ghana is situated on the coast of West Africa between latitudes $4^{\circ}44'N$ and $11^{\circ}11'N$ and longitudes $3^{\circ}15'W$ and $1^{\circ}12'E$. The area of the country is $238\,539\text{ km}^2$ of which $8\,482\text{ km}^2$ are covered by Lake Volta. The country is divided into nine political regions of which the Western, Central, Eastern, Ashanti and the Southern portions of Brong-Ahafo and Volta Regions lie in the closed forest zone while the Upper Northern and the Northern sections of the Brong-Ahafo and Volta Regions lie in the savanna zone. The ninth region, Greater Accra, is a small region carved out of the Eastern region.
2. The population of some 14 million is mainly agricultural and practices shifting agriculture for staple food crops. In the Southern sector of the country this type of agriculture also takes place adjacent to the production of cocoa, oil-palm and coffee. Cocoa is the main export crop contributing some 60% of the total export earnings followed by minerals then timber and timber products. Exports for the ten-year period (1966-1975) were valued at cedis (¢) 597.41 million or about US\$ 600 million and as the third largest export earner, forestry is seen as a major sector in the national economy.

1.2 Forest Types and Areas

3. There are two broad vegetational types in the country, viz. the Tropical High Forest (referred to locally as Closed Forest or Rain Forest) and the Savanna Forests. The Tropical High Forest Zone Covers the South-Western part of the country with a narrow strip in the Volta region and the two areas total $82\,580\text{ km}^2$. Ecologically, these forests have been divided into the Rain Forests with one floristic association (Cynometra-Lophira-Tarrietia) and the Moist Semi Deciduous Forests with three associations (the Lophira-Triplochiton, the Celtis-Triplochiton and the Antiaris-Chlorophora). In the following study the term Rain Forest, unless qualified, will be used loosely to cover the Tropical High Forest zone. The remainder of the country is covered by savanna formations extending to $156\,884\text{ km}^2$. The Rain Forest is the source of timber for both export and domestic markets and the savanna areas make a large contribution to the energy requirements of rural populations.

1.3 Demands on the Forest and the Forest Policy

4. National demands on the forest fall under two broad headings namely the provision of timber, fuel and other materials (the direct benefits) and the services or protective functions which the forests render (the indirect benefits).
5. With regard to the direct benefits derived from the forest, some indication is given from the out-turn and value recorded by the Ghana Forestry Department in 1975 when the volume of timber and fuelwood amounted to 16.8 million m^3 valued at ¢ 241.5 million. In addition to supplying the domestic market and maintaining an export trade in timber products pulp wood will be required for a planned pulp mill and additional fuelwood for a projected iron and steel industry.
6. In the case of indirect benefits, the protective role of the forest was of major concern in the early stages of development and remains so today. This view was reflected in a statement presented to the Empire Forest Conference in 1928 which stated "The Gold Coast (Ghana) has come to depend, for its prosperity mainly on the cocoa tree and the cocoa tree depends upon the forest for the maintenance of conditions of soil and atmospheric moisture which are essential for its health". Other statements drew attention to

the extent of soil erosion in the savanna zone, especially in the catchment areas of important rivers, and the fact that streams were in spate after every rain yet dry soon after the rain ceased. This concern for the protective functions of the forests still prevails, has influenced the choice of sites for reservation, the choice of management options within the reserved forests and is entrenched in the country's forest policy, the important clauses of which are:

- (i) The creation of permanent forest resources by the reservation of suitably situated areas of forest or land desirable and suitable for afforestation of a total extent sufficient to supply the benefits necessary for the welfare of the people including indirect benefits in the form of preservation of water supplies, maintenance of climatic conditions favourable to the principal agricultural crops and the control of erosion and to supply direct benefits in the form of sustained and adequate amounts of forest produce to satisfy the actual and potential requirements of the domestic and export market.
- (ii) The management of the permanent forest estate to achieve maximum productivity and value in perpetuity.
- (iii) The conduct of research into all branches of scientific forestry, especially in ecology and silviculture in order to achieve the aims of clause (ii).
- (iv) The cooperation with all agencies interested in optimum land use.

7. While the foresters of Ghana realise the fundamental importance of the indirect benefits of the forests, other groups including shifting cultivators, cocoa growers, timber concessionaires and some politicians are prepared to trade short-term gains for narrow sectoral interests against the long-term benefits to the population as a whole. As a result the forests are under continuous pressure from opposing interests.

1.4 The Development of Forest Management

8. The organised shipment of timber from the Gold Coast began about 1890 and in the following year 3 360 m³, mainly of mahogany (Khaya and Entandrophragma), were shipped to the United Kingdom. By 1913, the volume exported had risen to 93 480 m³, mainly from the South-West corner of the country and within convenient hauling distances from the Ankobra and Tano rivers and the Sekondi-up-country railway. The present relatively poor stocking of mahoganies in the South-West rain forest is believed to be due to this early, heavy exploitation. As railways were opened in the 1920's more of the rain forest became accessible and it became necessary to enact legislation to control exploitation and protect the Chiefs (who were custodians of forested lands) against unscrupulous entrepreneurs. Important landmarks in the early history of forest management include:

- 1900 - Concessions Ordinance
- 1907 - Timber Protection Ordinance enacted
- 1908 - Survey of the forests
- 1909 - Establishment of the Forest Department
- 1921 - Introduction of Property Marks under Timber Protection Rules
- 1927 - Forest Ordinance enacted

9. As a result of the 1908 survey of the forests, the reservation of selected areas became the first priority of the newly created Forest Department in 1909 but local opposition to reservation by the Chiefs obstructed progress and the Department was closed down

between 1916 and 1919. On re-activation, reservation commenced slowly and by 1923 some 260 km² had been reserved and by the early 1930's this had risen to 6 240 km² out of a target of 15 600 km² in the rain forest zone.

10. By 1936 concern was being expressed for the Savanna zone and the population who had to battle against severe climatic conditions and in some cases famine. Consideration was also given to how forestry might ameliorate conditions. The Sahelian threat was recognized about this time as was the need to trace the ecological progression from the Sahara through open forests to the rich forest areas of the South-West. To further the understanding of the principles involved, a forest officer was posted to the North in 1938.

1.5 Development of Forest Laws

11. The forest laws of Ghana may be grouped under three categories, viz. Reservation Laws, Forest Resource Protection Laws and Timber Trade Laws. The first attempt to enact reservation laws was made in 1910 but this met with fierce opposition from the Chiefs and although withdrawn that year, was passed by Legislative Council as the Forest Ordinance in 1911. Because of continued opposition from Chiefs and an educated elite which sent a delegation to the Secretary of State in London, assent to the Ordinance was withheld and a review commission set up. This commission recommended that the State should control the forest resources and that the Forest Ordinance should be enforced but with the outbreak of the First World War and the closure of the Forest Department, the Ordinance was not enacted.

12. In 1935, a revised Forest Ordinance was enacted which provided for:

- (i) The Governor to constitute into a reserve, Government, tribal, 'Stool' or private land (at the request of the Stool or the private owner) or any land which in the opinion of the Forest Department should be reserved to safeguard water supplies, wild animals, minerals, etc.
- (ii) The procedure for reservation including notification of intention to reserve, appointment of a settlement commissioner, restriction of rights, exclusion from reservation and compensation for commuted rights.
- (iii) Ensuring no change of land ownership as a result of reservation.
- (iv) Management of a reserve at the option of the Governor.
- (v) Definition of offences and sanctions to be imposed.

13. Alongside the 1935 Ordinance, bye-laws were prescribed enabling Native Authorities to constitute forest reserves and many Chiefs, especially in Ashanti, took advantage of these provisions to avoid compulsory constitution under the Ordinance. These bye-laws did not ensure management and they were later replaced by Rules which caused the local authorities to manage the reserves in accordance with the advice of the Forest Department. Difficulties arose over the settlement of commuted rights and the Ordinance was amended in 1949 to streamline procedure and payment for loss of rights.

14. The Timber Protection Ordinance of 1907 had proved ineffective for the control of exploitation outside the permanent forest estate and in 1959 a Protected Timber Lands Act was enacted to control the destruction of trees in forests outside reserves and farming in such areas. Enforcement of the Act proved almost impossible although it had the effect of slowing down shifting cultivation.

15. Sweeping powers were placed in the hands of the Executive when in 1962, the Administration of Lands Act was promulgated. This permitted the President to intervene in any proceedings relating to any stool land to the exclusion of the Stool concerned and because of abuses in the grant of timber concessions, the Lands Commission now holds and manages any land vested in the Head of State to the exclusion of all others.

16. Under the category of forest resource protection laws are grouped the laws which regulate the grant of timber concessions and felling agreements, the exploitation, define offences and prescribe penalties for such offences. Up to 1900 a number of enactments had attempted to exercise control over land and hence the forest resources with little success. The Concessions Ordinance of 1900 (and a similar one for Ashanti in 1903) sought to regulate concessions but failed to provide guidance on who was qualified to negotiate for a concession or prescribe the means of ensuring rational exploitation. In 1925 and 1926, amendments were made which gave the Chief Conservator power to regulate operations within concessions, to lay down directions and limitations before working commenced and to prescribe penalties for infringements. In 1939 the Concessions Ordinance with Amendments in 1946 defined in greater detail the regulatory powers of the Chief Conservator and the Timber Protection (Property Marks) Regulations of 1946 gave him complete control over the registration and use of property marks.

17. The more recent Forest Protection Decree of 1974 has been described as "the bedrock of forest protection in the country". This decree prohibits, within a forest reserve, and without written permission from the competent Authority, the felling, uprooting, injuring, etc., any tree or timber; cultivating a farm or erecting a building; setting fire to grass or herbage; causing damage by negligent felling; obstructing the channel of a river or stream; hunting or fishing; removing forest produce or pasturing cattle or permitting cattle to trespass. Other offences, e.g. altering or defacing boundary marks, failing to assist a forest officer to extinguish a forest fire are described and penalties for infringements are laid down including, for a second offence of illegal felling within a reserve, a fine not exceeding five thousand cedis (¢) or imprisonment for a term not exceeding ten years, or both.

1.6 The Extent of Forest Reservation

18. In spite of past suspicions by the Chiefs concerning the purpose of reservation and the attitude of Government towards their lands, Ghana now has a permanent forest estate of 16 788 km² or 20.41% of the total land area of the Rain Forest Zone and 6 810 km² or 6.97% of the Savanna Zone. Reservation within the Rain Forest Zone is now largely completed but efforts continue in the Savanna Zone. The reserves have been demarcated, almost all have been legally constituted and the estate is patrolled to prevent encroachment or illegal exploitation. All costs involved in the constitution of the reserves have been borne by Central Government in addition to the maintenance and protection of the reserves.

1.7 Socio-Economic Factors Influencing Management

19. Among the social factors which influence management is that of land ownership. In 1948 it was pointed out when considering the allocation of land to agriculture, grazing and forestry, that in the Gold Coast, the Colonial Government had never laid claim to land in any part of the country and that ownership was vested in the indigenous people. The policy has been continued by successive governments after independence and the President holds all public land and land specifically vested in him by law, in trust for the indigenous population who are the ultimate owners. Forest reservation does not alter

land ownership except in isolated cases where ownership disputes forced Government to purchase outright. This brings into focus the system of land tenure in Ghana and its impact on forest management, particularly the acquisition of forest concessions and the disbursement of forest revenue.

1.8 Land Tenure and Associated Problems

20. Land tenure systems in Ghana have been classified in four categories. These are:

- (i) Private land, including family land;
- (ii) Stool/Skin land;
- (iii) Stool/Skin land vested in the State in trust for the owners;
- (iv) State or Government land.

The private lands are those in private ownership or individuals and (restricted) families while Stool/Skin lands are those controlled by a Stool, the head of a particular community or family, for the benefit of the subjects of that Stool or the members of that community or family. The Skin in Northern Ghana is seen as the equivalent of the Stool in the South, i.e. the symbol of authority of the person exercising control over a community, clan, company, tribe or state and their lands. In this context the family is used in the Ghanaian tradition of an extended family.

21. Since forest reserves are deemed to be lands vested in the President they should, by law, be managed by the Lands Commission but in practice the actual management is carried out by the Forestry Commission although concessions and timber leases are awarded by the Lands Commission who also collect rents and royalties. In addition, the right of the Forestry Commission to collect revenue and royalties in respect of Stool lands is subject to the superior power given to the Administrator of the Stool lands by an Act made under the 1979 Constitution. The grant of concession is also complicated by inadequately defined Stool boundaries, absence of records of land transactions and disputed titles to ownership.

1.9 Conflicts between Forestry and Other Land Uses

22. In addition to the problems posed by shifting agriculture by the small farmer and encroachment for illegal cocoa cultivation there is an increasing trend towards commercial farming for such crops as oil-palm in the Southern sector and large-scale rice and maize growing in the Northern sector. Some of these schemes are financed externally by such bodies as the World Bank, the Commonwealth Development Corporation and the European Economic Community and the trend has stimulated calls for the release of forest reserves to agriculture, calls which politicians may find difficult to resist. Losses to the forest estate have also occurred by flooding for hydro-electric schemes and by mining for minerals such as bauxite. In the forestry sector itself changes in the demand for forest-based products influence the choice of management options, e.g. the increased demand for industrial cellulose and for pulp wood has led to current conversion of Subri Forest Reserve from natural forest to plantations of Gmelina arborea with the assistance of the United Nations Development Programme.

23. As in most developing countries conflicts between land use agencies and changes in the socio-economic situation will continue in the foreseeable future and forestry will be under increasing pressure from other forms of land use which generally regard forested land as idle land unless under intensive management. This would suggest a re-appraisal of existing forest management with perhaps a shift towards intensive multiple use of the forest estate.

1.10 Management Objectives

24. Management objectives are summarized in the Forest Policy as "The management of the permanent forest estate by methods that will achieve maximum productivity on the basis of sustained yield". Emphasis is therefore placed on the rain forest as a source of timber for the domestic and export markets and the savanna as a source of small timber, poles and fuelwood for the local population bearing in mind the protective functions of the forest and the need to satisfy the genuine requirements of the surrounding population for arable land and in addition the overriding need to ensure that these goods and services will be available in perpetuity.

1.11 Financing Forest Operations

25. The Central Government meets the salaries of all monthly paid staff and all costs incurred in forest reservation and protection. Under the Forest Improvement Act (1960) a percentage of all revenue accruing to any reserve is to be set aside for silvicultural and other improvement work within the reserve. Major development works such as large afforestation or reforestation schemes are paid for by the Central Government from a development vote.

1.12 Forest Management Authority

26. The Forestry Commission is now the main forestry authority of the country and has incorporated the Forest Department, the Forest Products Research Institute, the Division of Wildlife and National Parks and the Timber Marketing Board. The Forest Department is the authority responsible for forest management and is composed of four divisions viz. The General Conservation Division representing the executive arm of the Department and which has thirty-one forest districts spread throughout the country, the Education Division, the Planning Division which is responsible for the preparation of working plans and the Utilization Division. In addition to these, the Lands Commission is responsible for the award of timber leases and concessions (paragraph 21). The boundaries of each of the thirty-one districts of the Forest Department generally coincide with those of the political administrative district and there are twenty-one forest districts in the Rain Forest Zone and ten in the Savanna Zone.

1.13 Staff

27. Inadequate numbers of trained staff in the Forest Department is a handicap to forest management. The staff situation in the Department in 1982 was as follows:

| | <u>Establishment</u> | <u>Posts filled</u> |
|------------------|----------------------|---------------------|
| Professional | 46 | 27 |
| Senior Technical | 154 | 128 |
| Technical | 500 | 465 |

1.14 Wood Processing Industries

28. In order to shift the emphasis from the export of logs to that of processed wood the number of processing factories has been increased and at the close of 1977 there are 85 sawmills, 8 plywood plants and a chip-board factory, all located in the Rain Forest Zone. These plants have been operating below capacity largely because of the lack of spare parts. In 1979, a ban was imposed on the export of 14 species in log form but the industry has not yet seen the effect of the ban.

2. PRESENT FOREST MANAGEMENT

2.1 The Rain Forest

2.1.1 General Overview

2.1.1.1 The Extent of the Forest

29. The climatic zone characterized vegetationally by the Tropical Rain Forest covers 82 576 km² (paragraph 3), has uniformly high temperatures, a two-peak rainfall regime with an annual average of 2 125 - 3 000 mm in the South-West, falling to 1 250 - 1 375 mm, in the North-East and high relative humidity. These environmental factors make the zone suitable for the cultivation of such agricultural crops as cocoa, oil-palm, rubber, coffee and kola nuts. Population averages 62 inhabitants/km².

30. In 1975 the Forestry Department estimated the forested area in the Rain Forest Zone to be 19 865 km² and that in the previous 18-year period some 7 644 km² had been lost to other forms of land use. The permanent forest estate extends to 16 800 km² and the loss of forested areas has taken place mainly in the unreserved forests. It would appear that in the near future the permanent forest estate will be the only source of timber and if the forests are to maintain the present level of contribution to the economy, sound management principles must be applied.

2.1.1.2 Structure and Composition of the Rain Forest

31. The structure and physiognomy of the Tropical High Forest has been well documented and the heterogeneous nature of its floristic composition is of particular interest. An average of 130 species achieving timber size are present in any one community, some 360 such species have been recorded in the whole country and of the 80 of these which reach merchantable size and in commercial quantities, exploitation is biased towards only about 20 species. Forest Department records indicate that only 12 species, mostly Meliaceae, are regularly exploited and of these, 8 account for 90% of the total production thus giving rise to management and silvicultural problems.

32. The forest exhibits a three-storey structure in addition to the ground flora and shrub layer. There is a lower storey of heavily branched trees of about 20 m height, a upper canopy of up to 40 m height and a discontinuous emergent layer of up to 65 m. The constituents of the upper canopy and the emergent layer provide the main commercial timbers.

2.1.1.3 The Role of the Rain Forest

33. The forest reserves of the Rain Forest are classified as either productive reserves or protection reserves, the latter reserves (or parts thereof) being devoted to protection of the soil, waterways, unique flora, etc. and from which timber exploitation is excluded. The productive areas make up 83% of the reserved forests and the object is to manage for timber production on a sustained yield basis, a policy which was formulated in 1946 and receives the Governor's approval in 1948.

2.1.1.4 Volume of the Growing Stock and Implications for Management

34. Enumeration of the growing stock commenced in 1952 and was completed in 1973 using 2-5% stratified random sample plots over an area of 10 400 km². Results indicated a total volume of 550 million m³ of which 176 million m³ were of commercial species, this

latter being made up 132 million m³ of mature and over-mature stock and 42 million m³ of immature trees. Since 1971 the management aim has been to remove the over-mature stock on a 15-year felling circle with minimum girth limits of 11 feet and 7 feet (107 and 68 cm dbh), depending upon species, being used to determine whether or not a tree should be classified as over-mature.

35. Two important factors in future management became clear from the enumeration. The first was that only 26 "economic" species were exploited compared with some 334 "secondary timbers" and therefore any concept of sustained yield implied sustained yield of the "economic" species. The second factor emerging was that the percentage of "economic" species present in the several associations of the rain forest varied widely and therefore a common management system throughout the rain forest was not appropriate. Thus, in view of the paucity of "economic" species in the Cynometra-Lophira-Tarrietia association it became apparent that this forest type should be converted to plantations (preferably fast-growing species for industrial wood) and that the richer Celtis-Triplochiton association might be worked on a selection system.

2.1.1.5 The Selection System of Ghana

36. The selection system as applied in Ghana involved the stock mapping of "economic" species of more than 2.1 m girth (67 cm dbh), the improvement thinning of immature stock and the selective felling of mature trees on a pre-determined period of years and to a pre-determined yield at each cycle or period.

37. For management purposes the forest is divided into compartments of 128 ha and each compartment traversed systematically to measure, number and note the position of economic trees of more than 2.1 m girth. A stock map is then prepared at a scale of 1:2 500 to show by means of colours and symbols the species, girth and position of each economic tree together with a summary of the stocking by species and girth. From the stock map the yield is selected for exploitation and an estimate made of the distribution and species composition of the seed bearers to remain.

38. Improvement thinning is undertaken to free the 0.3-1.5 m girth (10-48 cm dbh) classes of "economic" species from the competition of climbers and less valuable trees. "Heavy" thinnings are undertaken to release Class I species and all non valuable species within a radius of 4 m are cut or poisoned. Beyond 4 m, any tree of lesser value suppressing the Class I species is also cut or poisoned. "Light" thinnings of a similar nature are applied to assist Class II trees and species are allocated to Classes I to IV on current economic value.

39. Improvement thinnings began as post-exploitation treatments but were later combined with stock mapping and referred to as "combined operations". Some 312 km² were treated annually between 1958 and 1971 when the treatment was discontinued because of grave doubts concerning the efficacy of the system.

40. The yield is regulated under a system in which trees of more than 1.5 m girth (48 cm dbh) will give equal annual yields for the period up to the time when the current immature trees attain exploitable sizes. Volume tables are unavailable and basal area, which is believed to bear a direct relationship to volume in respect of trees over 3 m girth is used. The time which trees take to pass from 1.5 m girth to exploitable size has been estimated as follows:

| | | |
|------------|-------------------|----------|
| Class I a | 1.5 - 3 m girth | 60 years |
| Class I b | 1.5 - 3 m girth | 45 years |
| Class II a | 1.5 - 3 m girth | 50 years |
| Class II b | 1.5 - 2.1 m girth | 30 years |

The exploitable yield is calculated (the Kinloch/Jack method) by dividing the total hoppus basal area of all trees above 1.5 m girth by the time of passage. The calculated yield is justified by the forecast method of projecting the growing stock, less the annual yield, to the next felling cycle assuming a 75% survival rate. The felling cycle until 1971 was 25 years and the area of the annual coupe obtained by dividing the area of the felling series, working circle, etc. by the period of the cycle. The yield is selected from the upper girth classes downwards until the prescribed yield is reached, minimum girth limits being enforced.

2.1.1.6 Reforestation

41. To meet the demands of local populations for land, the taungya system was introduced on a widely distributed basis which complicated management and had limited success. Large-scale plantations were therefore commenced in 1968 and by 1977 some 40 000 ha had been laid down. However, the success rate did not exceed 60%. The annual planting target from 1980 was set at 10 900 ha.

42. The major species used have been Terminalia ivorensis, Tectona grandis, Cedrela odorata, Gmelina arborea, Mansonia altissima, Triplochiton scleroxylon, Tarrietis utilis and various eucalypts and pines of which Pinus caribaea var. hondurensis has done best. None of the valuable and indigenous export timbers have performed well in plantations either because of insect attack, e.g. the Khaya and Chlorophora, or because of difficulties in procuring a regular supply of seed, e.g. Triplochiton.

43. Reforestation involves clear-felling, burning and planting blocks of pure species. The implications of this system in relation to the effects on the environment and later biological problems, e.g. soil deterioration and the incidence of insect attack, are now being studied. With Canadian assistance, a programme of study has been undertaken to determine the extent to which agri-silviculture can be applied to reforestation and to quantify the benefits to be obtained.

2.1.1.7 Management Problems of the Rain Forest

44. From the viewpoint of management of the Rain Forest the basic problems are concerned with the relatively small proportion of the forest which is made up of economic species and secondly with difficulties associated with increasing the proportion of "economics" as a post-exploitation effect on the composition of future stands. With regard to the first of these the solution must include more efficient harvesting of the economic species and also increasing the number of species which are commercially acceptable. This might be done by improved processing techniques and by more aggressive marketing but such matters lie outside the scope of this study.

45. In the case of the second problem area, i.e. increasing the proportion of economic species in the post-exploitation crop, one of the criticisms of the "combined operations" (paragraph 39) was that the species poisoned might later become species of commercial value, e.g. Pericopsis elata, then considered worthless but now the highest priced timber species. The tropical shelterwood system was tried in efforts to secure desirable regeneration but abandoned because of the preponderance of non-commercial species regenerating

and the paucity of the commercial species. Unfortunately inadequate ecological and silvicultural knowledge concerning the requirements for the optimum establishment of economic species still persists. A further cause for concern is that yield regulation, which is based upon the estimated growth rate of the various classes, might be leading to over-cutting because of inaccuracy of the data on which the estimates are based. Other constraints on management include deficiencies in the award of concessions leading to unsatisfactory exploitation and the widespread occurrence of illegal felling, the penalties for which seem completely inadequate.

46. Illegal felling and encroachment are symptoms of a lack of sympathy and understanding on the part of the rural population who see the reserves as "Government land" and therefore a potential source of land for agriculture. Some means must be found of involving the local population in the management of the reserves and participating in the goals of production and conservation in spite of economic difficulties which have reduced the allocation of funds for development and maintenance work.

2.1.2 The Kakum Forest Reserve

2.1.2.1 General

47. The previous chapter has dealt with the management of the Rain Forest in general terms. In this chapter management is discussed in relation to the Kakum Forest Reserve. The Reserve covers an area of 214 km² and is one of thirteen forest reserves within the Cape Coast Forest District. The Reserve, with two smaller reserves (total area: 394 km²), are located within the Rain Forest Zone while the remaining ten reserves are smaller plantations in the littoral zone. The staff responsible for the Reserve are: 1 Senior Assistant Conservator (part-time), 2 Technical Officers (part-time) and 7 Forest Guards (full-time). Although the population around the Reserve was sparse some twenty years ago, migration to the area in recent years has brought pressure on farm land and unreserved land in the vicinity of the forest. Employment opportunities for the local population are limited.

2.1.2.2 Demands on the Forest

48. The Reserve remains free of encroachment but it lies in a zone designated for oil-palm and citrus and is also suitable for cocoa. In addition to the cultivation of these crops the local population cultivates staples, e.g. plantain, maize, cassava, etc. and their major demand is for arable land. As far back as 1947 there were requests by local Chiefs for a taungya scheme with the Chiefs prepared to organize tree seed collection for the taungya so the demand was genuine. Now, with a greatly increased population in the district this demand for land is likely to intensify and must be taken into account when management options are considered.

49. Within the Central Region in which the Reserve is situated, 80% of the population use wood as the only source of fuel. In addition, fuelwood is an important trade commodity between the population adjacent to the Reserve and the coastal fishing community which requires large amounts for smoking fish. Other industries within the Region depending upon the forests for fuel are a brick and tile factory and a ceramics factory. Other important markets include the Greater Accra Region situated at a distance of 200 km, which uses large quantities of fuelwood. The species favoured for fuel include Celtis spp., Albizia spp., Fagara spp. and Manilkara spp., the latter particularly for smoking fish.

50. Other demands for forest produce include Astonia booni for carving trays, a number of species for building poles, tool handles and wood carving and canes, palm and raphia for

basket weaving. In 1958, some 13 000 poles were required to carry telephone lines and a similar demand may be expected for rural electrification.

51. The main species cut for export were the Khayas, Entandrophragma cylindricum, E. utile and E. angolense. The gold mines in the Western Province provided an alternative market for the mahoganies in addition to Nauclea diderrichii, Lophira alata, Chlorophora excelsa and Nesogordonia papaverifera.

2.1.2.3 Reserve Selection, Constitution and Legal Position

52. The Kakum Forest Reserve was selected and demarcated in 1925-1926 and the survey and placing of boundary pillars completed in 1931. The Reserve Settlement Commissioner, in his judgement of competing claims to the land covered by the Reserve, decreed that the land was shared between two families and three Stools in areas which varied from 4.26 km² to 97.99 km².

53. The Reserve is covered by five concession agreements and one felling agreement and the terms which were negotiated with the various owners varied in respect of annual rents, royalties, period of validity and conditions of renewal.

2.1.2.4 Forest Type and Species Composition

54. Although the vegetation map of Ghana places the Reserve within the Lophira-Triplochiton association a 5% random sample enumeration of 1957 indicates that species composition makes the type more akin to the Celtis-Triplochiton association.

55. Among the economic species, the most commonly represented of the Meliaceae are Turraeanthus africanus, Guarea cedrata and Entandrophragma angolense. Stocking of E. candollei was poor and that of E. cylindricum only fair. Other economic species represented are T. scleroxylon, Chlorophora excelsa, Tieghemella heckelii, Nauclea diderrichii, Terminalia ivorensis and Mansonia altissima.

2.1.2.5 Management Objectives, Plans and Execution in the Kakum Reserve

Objectives

56. The stated objectives of management are:

- (i) To protect the environment from the effects of shifting agriculture;
- (ii) To maintain a permanent source of timber for local needs and for export;
- (iii) To meet the local demand for other forest produce.

Working Plans

57. A working plan was approved for the period April 1952 to June 1957, revised for the period July 1958 to June 1963 and again for the period July 1963 to June 1978. No further revision has as yet been made. Modifications to the working plan were made at the times of revision and these are dealt with below.

58. The first plan divided the Reserve into three working circles, viz.

- (i) A Research Working Circle of 81 ha;
- (ii) A Selection Working Circle consisting of the areas covered by the Concessions and the Felling Agreement;
- (iii) A Protection Working Circle covering the remainder of the Reserve. No silvi-cultural system was prescribed and the felling cycle of the Selection Working Circle was fixed at 10 years.

59. The Research Working Circle was devoted to experimental work to determine whether natural regeneration of the economic species could be obtained by application of the Tropical Shelterwood System. The area was divided into 3 blocks and one block treated in each of the years 1947, 1948 and 1949. Seventeen trees were felled when exploitation became due in 1953 and because no concessionaire would take the remainder of the yield, 106 commercial trees had to be poisoned. Regeneration counts suggested that the expense involved in the Tropical Shelterwood System was unjustified, the System was abandoned and the area line planted in 1956 with economic species.

60. The Protection Working Circle was designated in the 1952-57 Working Plan although no reason was given for its constitution other than that it incorporated areas not covered by validated concessions. In the 1963-78 revised Working Plan the provision of a Protection Working Circle was excluded although the protective role of the Tropical High Forest was a concept inherent in the Plan

61. The Selection Working Circle was composed of that part of the Reserve which was to be intensively managed for the production of timber. The system has already been described in general terms (paragraphs 36-40) and in the Kakum Reserve modifications were made to accommodate small concession holdings which could not otherwise be worked as economic visits, in addition to regulating the activities of concessionaires with holdings in other Reserves. The Selection Working Circle under the 1952-57 Working Plan was divided into three felling series, viz.

- | | |
|---------------------------|----------|
| (i) The North-East F.S. | 6 120 ha |
| (ii) The South-East F.S. | 2 753 ha |
| (iii) The South-West F.S. | 3 767 ha |

Total 12 640 ha

62. The North-East F.S. was divided into ten annual coupes (10-year felling cycle) each of 612 ha and each coupe into five compartments of approximately 120 ha each. Between 1952 and 1955, twenty-three compartments were stock surveyed and ten harvested. For the South-East F.S. it was prescribed that, in order to provide an annual area large enough for economic exploitation, the entire felling series would be worked in four years and in the period 1952-55, 1 222 ha were demarcated, stock surveyed and harvested. No work was done in the South-West Felling Series.

63. Amendments made in 1955 because of the bankruptcy of a concessionaire and the desire to incorporate the exploitation of Kakum with other reserves, resulted in the felling cycle being extended to 15 years and prescriptions made for improvement thinning (paragraph 38). To provide a basis for a reasonably accurate estimate of the growing stock, 5% enumerations using stratified random samples were made in 1957 and from the data

it was possible to calculate a Reliable Minimum Estimate of the basal area per sample and this was used as a basis for future yield control.

64. At the two revisions (1958 and 1963) the Objects of Management remained much as those outlined in paragraph 56 although emphasis was laid on sustained yield and improvement of the growing stock.

2.1.2.6 The Greater Kakum Working Plan

65. At the revision of the Kakum Working Plan in 1963 the opportunity was taken to incorporate four other Reserves (Ajuesu, Assin, Apimanim and Pra-Suhein I and II) with a total productive area of 403 km² of which 376 km² constitute the Selection Working Circle. The whole of the Kakum Reserve area, 213 km², falls within this Working Circle.

The Selection Working Circle

66. The Working Circle was divided into four Felling Series, viz.

| <u>Name</u> | <u>Total Area</u> (km ²) | <u>Area in Kakum</u> (km ²) |
|--------------------|---|--|
| Briscoe F.S. | 223 | 114 |
| Pans F.S. | 63 | 58 |
| Gaisie F.S. | 24 | - |
| Miscellaneous F.S. | 67 | 36 |
| Total | 377 | 208 |

Each felling series represented the total holding of the concessionaire within the Working Circle and the Miscellaneous Felling Series is made up of areas covered by four felling agreements. Yield in respect of each Felling Series was controlled by area of the F.S. and maximum basal area and girth limits as outlined in paragraph 40.

Calculation of the Yield

67. The yield calculation for Class Ia species in the Gaisie F.S. is illustrated below.

| <u>Class</u> | <u>Species</u> |
|-----------------------------|------------------------------------|
| <u>Class I Species</u> | <u>Chlorophora excelsa</u> |
| | <u>Entandrophragma cylindricum</u> |
| | <u>Entandrophragma angolense</u> |
| | <u>Khaya ivorensis</u> |
| | <u>Tieghemella heckelii</u> |
| | <u>Nauclea diderrichii</u> |
| Net productive area of F.S. | 2 678 ha |
| Felling cycle | 25 years |
| Annual coupe | 107 ha |

Yield Calculation for Class I Species

| Girth (m) | 0.91-1.52 | 1.53-2.14 | 2.15-2.74 | 2.75-3.35 | 3.36-3.96 | 3.97-4.57 | 4.58+ |
|------------------------------------|-----------|-----------|-----------|-----------|-----------|-----------|-------|
| No. of trees on 1 018 ha | 439 | 554 | 414 | 325 | 137 | 137 | 32 |
| Basal area (m ²) | | 147.4 | 195.8 | 240.2 | 145.8 | 198.5 | 60.9 |
| Total basal area (m ²) | | | | 988.6 | | | |

Estimated basal area on F.S. of approximately 2 678 ha = $\frac{988.6 \times 2\ 678}{1\ 018} \text{ m}^2$

Annual Yield by Kinloch and Jack with 60 divisor (paragraph 40) = $\frac{988.6 \times 2\ 678}{1\ 018 \times 60}$

= 43.34 m²

Apportionment of Yield

| Girth (m) | 1.53-2.14 | 2.15-2.74 | 2.75-3.35 | 3.36-3.96 | 3.97-4.57 | 4.58+ |
|--|-----------|-----------|-----------|-----------|-----------|-------|
| No. of trees per coupe of 107 ha | 58 | 44 | 34 | 14 | 14 | 3 |
| Basal area (m ²) | 15.49 | 20.81 | 25.19 | 14.90 | 20.34 | 5.67 |
| Yield of 43.34 m ² from coupe | | | 2.43 | 14.90 | 20.34 | 5.67 |

i.e. all trees of more than 3.36 m girth plus 9.6% of the 2.75-3.35 m class.

68. The reserve, however, was subjected to salvage felling of all trees above 3.36 m girth on a 15-year felling cycle in 1971. This followed a decision in late 1970 to abolish "combined operations" and salvage fell all productive forest reserves scheduled for exploitation, in an effort to remove all over-mature trees.

69. Prescriptions were made in the Plan for returns and controls to be compiled of areas exploited, volumes and species cut and volumes of defective trees. Rules were laid down for field checking and forest officers were required to maintain a series of registers summaries which had to be submitted annually to the Chief Conservator. Unfortunately controls in respect of Kakum have not been submitted for work done after 1975.

70. The absence of control forms makes it impossible to calculate the ratio of exploited yield to prescribed yield but in the period 1964 to 1968 the ratio fell from 38% to 12% of the yield offered probably because Class III species were then offered for the first time and few if any were cut. During this period, approximately 55% of Class I and Class II species offered were cut.

it was possible to calculate a Reliable Minimum Estimate of the basal area per sample and this was used as a basis for future yield control.

64. At the two revisions (1958 and 1963) the Objects of Management remained much as those outlined in paragraph 56 although emphasis was laid on sustained yield and improvement of the growing stock.

2.1.2.6 The Greater Kakum Working Plan

65. At the revision of the Kakum Working Plan in 1963 the opportunity was taken to incorporate four other Reserves (Ajuesu, Assin, Apimanim and Pra-Suhein I and II) with a total productive area of 403 km² of which 376 km² constitute the Selection Working Circle. The whole of the Kakum Reserve area, 213 km², falls within this Working Circle.

The Selection Working Circle

66. The Working Circle was divided into four Felling Series, viz.

| <u>Name</u> | <u>Total Area</u> (km ²) | <u>Area in Kakum</u> (km ²) |
|--------------------|---|--|
| Briscoe F.S. | 223 | 114 |
| Pans F.S. | 63 | 58 |
| Gaisie F.S. | 24 | - |
| Miscellaneous F.S. | 67 | 36 |
| Total | 377 | 208 |

Each felling series represented the total holding of the concessionaire within the Working Circle and the Miscellaneous Felling Series is made up of areas covered by four felling agreements. Yield in respect of each Felling Series was controlled by area of the F.S. and maximum basal area and girth limits as outlined in paragraph 40.

Calculation of the Yield

67. The yield calculation for Class Ia species in the Gaisie F.S. is illustrated below.

| <u>Class</u> | <u>Species</u> |
|-----------------------------|------------------------------------|
| <u>Class I Species</u> | <u>Chlorophora excelsa</u> |
| | <u>Entandrophragma cylindricum</u> |
| | <u>Entandrophragma angolense</u> |
| | <u>Khaya ivorensis</u> |
| | <u>Tieghemella heckelii</u> |
| | <u>Nauclea diderrichii</u> |
| Net productive area of F.S. | 2 678 ha |
| Felling cycle | 25 years |
| Annual coupe | 107 ha |

Yield Calculation for Class I Species

| Girth (m) | 0.91-1.52 | 1.53-2.14 | 2.15-2.74 | 2.75-3.35 | 3.36-3.96 | 3.97-4.57 | 4.58+ |
|---|-----------|-----------|-----------|--|----------------|-----------|-------|
| No. of trees on 1 018 ha | 439 | 554 | 414 | 325 | 137 | 137 | 32 |
| Basal area (m ²) | | 147.4 | 195.8 | 240.2 | 145.8 | 198.5 | 60.9 |
| Total basal area (m ²) | | | | 988.6 | | | |
| Estimated basal area on F.S. of approximately 2 678 ha | | - | | $\frac{988.6 \times 2\ 678}{1\ 018}$ | m ² | | |
| Annual Yield by Kinloch and Jack with 60 divisor (paragraph 40) | | - | | $\frac{988.6 \times 2\ 678}{1\ 018 \times 60}$ | | | |
| | | - | | 43.34 | m ² | | |

Apportionment of Yield

| Girth (m) | 1.53-2.14 | 2.15-2.74 | 2.75-3.35 | 3.36-3.96 | 3.97-4.57 | 4.58+ |
|--|-----------|-----------|-----------|-----------|-----------|-------|
| No. of trees per coupe of 107 ha | 58 | 44 | 34 | 14 | 14 | 3 |
| Basal area (m ²) | 15.49 | 20.81 | 25.19 | 14.90 | 20.34 | 5.67 |
| Yield of 43.34 m ² from coupe | | | 2.43 | 14.90 | 20.34 | 5.67 |

i.e. all trees of more than 3.36 m girth plus 9.6% of the 2.75-3.35 m class.

68. The reserve, however, was subjected to salvage felling of all trees above 3.36 m girth on a 15-year felling cycle in 1971. This followed a decision in late 1970 to abolish "combined operations" and salvage fell all productive forest reserves scheduled for exploitation, in an effort to remove all over-mature trees.

69. Prescriptions were made in the Plan for returns and controls to be compiled of areas exploited, volumes and species cut and volumes of defective trees. Rules were laid down for field checking and forest officers were required to maintain a series of registers summaries which had to be submitted annually to the Chief Conservator. Unfortunately controls in respect of Kakum have not been submitted for work done after 1975.

70. The absence of control forms makes it impossible to calculate the ratio of exploited yield to prescribed yield but in the period 1964 to 1968 the ratio fell from 38% to 12% of the yield offered probably because Class III species were then offered for the first time and few if any were cut. During this period, approximately 55% of Class I and Class II species offered were cut.

Management Costs and Revenue

71. Paragraph 25 has outlined the expenditure borne by Government in connection with the Reserves. Revenue including concession rent, silvicultural fees levied per unit of area exploited and royalties are paid into the Forest Improvement Fund. The silvicultural fees go to the Forestry Department for forest improvement works and part of the remainder, usually 50%, after expenditure has been deducted, is disbursed to the land owners and the rest retained for improvement works.

2.2 The Wooded Savanna Zone

2.2.1 General Overview

72. The Northern part of the country is a zone of relatively harsh climatic conditions. The mean daily maximum temperature is 35.4°C , total precipitation varies from 1 000 to 1 250 mm/annum which falls between May and October followed by drought from November to April during which relative humidity remains at less than 30% at 15.00 hrs. The unfavourable rainfall pattern coupled with dry season fires exerts a degrading influence on the vegetation and shifting cultivation aggravates the situation. Under these circumstances the protection role of the forest is of major concern.

2.2.1.1 The Extent of the Savanna Woodland

73. The zone covers the whole of the Northern and Upper Regions and the Northern section of the Brong-Ahafo and Volta Regions and tapers in a Southerly direction to reach the sea in the Southern Volta Region at the Dahomey Gap. The zone covers an area of some 156 880 km², i.e. about two-thirds of the area of the country. The land use pattern may be summarized as follows:

| | | |
|--------------------------------------|------------------------|-----------------------|
| Forest Reserves | 8 810 km ² | (6% of area of zone) |
| Unreserved woodlands | 84 800 km ² | (54% of area of zone) |
| Other land (grass-land, farms, etc.) | 62 670 km ² | (40% of area of zone) |

It is estimated that some 380 km² of woodland is lost annually to shifting cultivation and other forms of land use.

2.2.1.2 Structure and Composition of the Savanna Woodland

74. The vegetation is typically short, heavily branched and widely spaced over a ground flora of tall grass. Two zones are distinguished, the Guinea Savanna of the South and the Sudan Savanna of the North. In the South, the Guinea type shows gradations into the Antiaris-Chlorophora association of the high forest but further North, in the Guinea zone proper the trees are more widely spaced, shorter and with semi-xerophytic and xerophytic species becoming more prominent. The Sudan savanna zone is restricted to the North-Eastern corner and woody vegetation is represented by Balanites aegyptiaca, Adansonia digitata, Sclerocarya birrea, Bombax costatum, Acacia spp. and Combretum spp. Within each zone, local variations due to edaphic and biotic factors occur.

2.2.1.3 Management of the Savanna Woodlands

75. Forest management within the zone has been confined mainly to that of reservation and data on forests and forest use are scanty although the need for the protection of catchment areas has been emphasized since 1945. The extent of reservation is limited to only 5.63% of the area and the objects have been to protect the catchment areas of the major streams, particularly the tributaries of the Volta, to provide a continuing supply of forest produce.

76. The sawn timber requirements of the area are met from the high forest zone of the South and the major use of the Savanna woodland has been for the supply of poles, fuelwood and other minor produce. Estimates of the out-turn of fuelwood in the Northern and Upper Regions in 1976 was estimated to be 1.48 million m³. Minor produce includes grass for thatching, the shea nut, Butyrospermum paradoxum for shea butter, Adansonia digitata fruits for sugar substitute and the fruits of Parkia filicordia for soups.

77. The major forestry operations consist of protection of the natural forest and the establishment of plantations. Early burning of the natural woodland is seen as the most appropriate method of protection and improving the growing stock although complete exclusion of fire, if this were practicable, seems to be the most effective method of improving the stocking of woody vegetation.

78. Data concerning the establishment of plantations including crop performance are scanty but the major species tried are Tectona grandis, Dalbergia sissoo, Anogeisus leiocarpus, Gmelina arborea and Azadirachta indica and the major constraint in all cases has been fire.

79. The other related forestry activity is that of wildlife protection. The Mole Game Reserve covering 4 940 km² is the first game reserve in the country and provides a habitat for numerous species of indigenous fauna. In addition the Bui National Park of 2 080 km² is located in the Savanna woodlands.

2.2.2 The Red Volta West Forest Reserve in the Savanna Woodland Zone

2.2.2.1 Situation, Area and Staff

80. The Red Volta West Reserve lies within the Navrongo District of the Upper Region and forms a belt along the west bank of the Red Volta River then subsequently along the north bank of the White Volta up to the Tamale-Bolgatanga motor road. The area of the reserve is 2 625 km² and the full-time staff employed in the reserve number four forest guards and fifteen labourers for plantation works. The Conservator, in whose charge the reserve is situated, is stationed in Bolgatanga.

2.2.2.2 Socio-Economic Factors Affecting Forest Management

81. Population density in the vicinity of the reserve is about 50 inhabitants per km² rising to some 200/km² in farming areas. The population is predominantly agricultural raising food crops at subsistence level. Several maintain fairly large herds of livestock and large-scale rice and maize cultivation has commenced to make demands on woodland areas. Farming methods are permanent around the scattered compounds with shifting cultivation and short fallow periods further afield. The major river valleys are not generally cultivated because of deteriorated soil and health hazards associated with sleeping sickness and onchocerciasis.

82. Apart from farming, employment opportunities are limited and rural industries are centred around carving, weaving and leather work. Per capita income is low and migration to the South in search of employment is common. The supply of fuelwood in the zone is inadequate and domestic energy requirements are frequently met from corn stalks and occasionally cattle dung. Livestock population is high and over-grazing serious in some areas. Woodland degradation has reduced stocks of tall thatching grasses generally and the reserves are becoming the only source of this material.

2.2.2.3 Management of the Red Volta West Forest Reserve

83. The reserve was demarcated in 1948 as a production reserve for the supply of poles and fuelwood to the surrounding population. A 1% enumeration was carried out in 1951 and between 1952 and 1960 708 ha were planted with T. grandis, A. leiocarpus, D. sissoo, G. arborea, M. inermis and C. excelsa. The latter, a high forest species was tried on the level soils but generally it failed.

84. The major operation currently undertaken is early burning as a protection against late dry season fires. The forest Products Research Institute has established trial plots of several species particularly acacias for gum production. Planned exploitation was never implemented, maintenance of reserve records has been poor and the most recent statement of accounts (1976) shows a debit balance of cedis 21 309.52 (approximately US\$ 8 124).

3. EVALUATION OF PRESENT FOREST MANAGEMENT

3.1 Management of the Rain Forest

3.1.1 Extent of Reservation

85. Reservation in the zone is virtually completed and some 20.4% of the total area of the zone has been legally constituted as Forest Reserve. Outside the reserves the forest has largely been destroyed by shifting cultivation or converted to other crops.

3.1.2 Economic Gains from the Forest

86. Economic gains may be assessed in terms of national gains or from the benefits derived by the Stools and private owners. Timber and the timber industry has contributed substantially to the foreign exchange earnings of the country and in the years 1976-1981 these earnings amounted to US\$ 41.9 million, 32.5 million, 43.3 million, 46.2 million, 39.2 million and 26.6 million respectively. (1 cedis = US\$ 0.36 approximately). A measure of the gains to land owners may be obtained by comparing revenue, expenditure and disbursements to land owners of the Kakum Reserve in 1973-74.

| | |
|----------------------------------|--------|
| Revenue (US\$ equivalent) | 16 194 |
| Expenditure " | 2 098 |
| Balance " | 14 096 |
| Disbursement to land owners " | 7 210 |

3.1.3 Yield Regulation and Control of Exploitation

87. Although the original method of yield regulation might have been effective it was replaced in 1970 by salvage fellings to girth limits of 3.36 m and on a felling cycle of 15 years compared with the former 25 years. Over-mature trees among the less popular species remained unexploited and, in effect, a more severe creaming of the forest resulted. The effects of this change are not yet known although the recently completed FAO/UNDP inventory may provide some information. Meanwhile, the feeling remains that salvage felling has led to over-exploitation of the economic species.

3.1.4 The Award of Concessions

88. Management has been affected by the efficiency of the concessionaires and this in turn is influenced by its financial standing, its equipment, the training of its personnel and by its ability to dispose of produce, especially timbers of Class II and Class III. Existing concessions and felling agreements were largely negotiated before the establishment of the Lands Commission and were frequently influenced by the pecuniary and personal advantages derived by the chiefs. Concession rents are low, some areas are too small to provide continuity of exploitation and in some cases concessions have remained unworked while adjacent sawmills had insufficient raw material.

3.1.5 The Effect of Royalty Rates

89. Royalties are uniform throughout the country and are based upon species regardless of volume and range from the equivalent of US\$ 2.40 to 6.40 per tree. Royalty rates have been revised but compared with the value of the logs obtained are still very low. Since

royalties are not payable on trees rejected after felling, concessionaires reject trees which are only slightly unsound or damaged and no effort is made to salvage remnants.

3.1.6 Improvement of the Growing Stock

90. There are two approaches towards the improvement of the growing stock, viz. that of ensuring optimum utilisation of the existing growing stock by encouraging the use of the secondary species and that of enhancing the regeneration, growth and development of the prime species. Since Kakum is relatively rich in economic species and does not therefore fall into the category of those to be converted to plantations of fast growing species, it is still necessary, however, to evolve a suitable system of natural regeneration to attain the desired improvement of the growing stock, the Tropical Shelterwood System having been abandoned (paragraph 59).

3.2 Management of the Wooded Savanna Zone

91. The reservation programme as initially planned was designed to protect the courses of the major streams and rivers and some success has been achieved in this direction yet only about 6% of the total area is under reservation. This percentage is very low in view of the degradation of the woodlands outside the reserved forest.

92. The intangible benefits which the reserves confer cannot be quantified and are probably not appreciated by the surrounding population whose main interest lies in financial gain and the reserve does not seem to have provided this. No record of disbursement of revenue to the land owners exists and the debit balance of US\$ 8 124 up to the close of 1976 suggests that there never will be one. Under these circumstances the land owners must view the reserve as idle land which could be put to profitable use.

93. It appears therefore that the management of the Ghanaian savanna woodland has not benefitted the local population who regards the reserves as land which could be put to better use. The solution may therefore be in more intensive multiple-use forest management to provide an improved living standard for the adjacent community.

4. FUTURE TRENDS IN FOREST MANAGEMENT

4.1 The Rain Forest

4.1.1 Multiple Use

94. To date management of the Kakum Reserve has been geared towards timber production with scant attention given to the potential of minor forest products to stimulate rural industry and the use of branch wood and rejected logs for fuelwood and charcoal. Employment in forest industry is minimal and the concept of forestry for rural development has been ignored. Only when the local population derives tangible benefits from the forest will it cease to regard the forest as "idle Government land" to be encroached upon when arable land is required and only then will it cooperate with management to achieve national objectives.

4.1.2 Timber Production

95. More intensive timber production hinges upon the use of the secondary species and should commence with the local use of such species to release more primary timbers for the export market and, in time perhaps, encourage the export market to accept at least some of these. To facilitate this, increased research into timber properties of the secondary species is required and where appropriate, preservative treatments devised. In addition maximum utilisation of all trees felled should be encouraged and where feasible, manufacturing plants set up near to the forest to reduce log transport costs and to encourage more intensive utilisation.

4.1.3 Award of Concessions

96. Experience suggests an integration of management with processing units should influence the award of concessions and it should therefore be obligatory for the Lands Commission to consult the Forestry Department before timber rights are awarded. The award of the concession should be contingent upon the ability of the concessionaire to establish a processing plant or a link with an existing plant and to furnish proof of adequate financial backing. The concessionaire should have assurance of renewal of the concession provided he has fulfilled the stated conditions, thus permitting him an assurance of raw material for any industries established and it should be declared unlawful for concessionaires to rent out their rights to third parties for financial gain.

4.1.4 Royalties

97. Royalties should be raised to a realistic level and consideration should be given for enforcing payment for the full amount of the prescribed yield and not for that portion of it which is felled and utilised. In addition royalties should be based upon species classes and the volume utilisable rather than the number of trees of each species class extracted. In addition, and in contra-distinction to what has been expressed in paragraph 96, the possibility of auctioning the prescribed yield of each coupe should be considered as existing concessions expire.

4.1.5 Improving the Growing Stock

98. Reference has already been made to the apparent failure of the Tropical Shelterwood System to obtain a satisfactory level of regeneration (paragraph 59), yet encouraging results have been obtained in Bobiri Reserve. Some Ghanaian foresters condemn "combined operations" (paragraph 39) while others claim enhanced growth in the smaller girth classes

in those areas which were so treated. It is clear that variables are operative which are not at present understood and renewed investigation so designed to provide statistically valid results is required to determine procedures for future silvicultural work.

4.2 The Wooded Savanna Zone

99. It seems unlikely that the savanna woodlands will ever contribute significantly to the timber resources of the country and management should therefore aim at providing environmental protection and such forest products as fuelwood, poles, wood for rural industries, e.g. carving, grass for thatching and edible fruits. Consideration must also be given to finding ways to give the land owners some material or pecuniary benefit from the reserve so that it is not regarded simply as idle land.

100. Further reservation would be highly beneficial for protective purposes and steps should be taken for the settlement and constitution of existing proposed reserves. Reservation alone, however, is unlikely to achieve success in an area where increasing population requires increasing areas of arable land. Management must be seen to be providing the fuelwood, the poles, thatch and other products required by the community and for this reason intensive multi-purpose management must be instituted.

101. An example of multi-purpose management (unfortunately discontinued) was provided in the North-East of Ghana. In this area which is heavily populated there is a catchment area which would normally have been considered for reservation. The policy adopted, was to constitute instead, land planning zones which were to be managed jointly by a team of administration, agricultural, animal husbandry, water supply and forest officers for the greatest joint benefits to the community and to this effect an enabling Land Planning Act was enacted. By the provisions of this Act burning was prohibited, non-arable land was reserved for forest growth, improved farming methods were introduced and grazing was controlled in sections of the woodlands.

102. This form of land management should now be revived and the participation of rural populations encouraged and increased efforts made to evolve a satisfactory and acceptable form of multi-use management.

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TRINIDAD AND TOBAGO

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1. THE BACKGROUND

1.1 General Description of the Country

1. The Republic of Trinidad and Tobago lies between $10^{\circ}2'$ and $11^{\circ}21'$ North latitude and $60^{\circ}30'$ and $61^{\circ}56'$ West longitude. Trinidad whose area is $4\,769\text{ km}^2$ is situated approximately 18 km East of Venezuela and geographically and biologically is closely related to that country. Tobago lies North-East of Trinidad, extends to 355 km^2 and is separated from Trinidad by a channel 35 km wide.

2. The climate of both Islands is tropical. The dry season lasts from mid-January until mid-May and the wet season from mid-May until the end of December. Annual precipitation in Trinidad varies from about 3 300 mm in the North and North-East to about 1 700 mm in the West and South-West. In Tobago the precipitation is greatest along the hilly spine forming the Main Ridge Forest Reserve and varies from 3 000 mm in the hills to a low of about 1 450 mm in the South-West.

3. The average annual day-time temperature is 29°C falling to 23°C at night and the average monthly temperature varying from a maximum of 32°C in May to a minimum of 19°C in February. Relative humidity is consistently high and frequently approaches saturation point at night although minima of about 40% occur in February and March. The prevailing winds are North-Easterly and blow consistently at from 8 to 40 km per hour. Trinidad and Tobago lie to the South-West of the path most commonly taken by hurricanes but at frequent intervals the Eastern coast of Trinidad and the Island of Tobago have been damaged by such storms.

4. Trinidad is divided topographically by three ranges of hills running in a general East-West direction and with two lowland plains lying between the three ranges. The Northern Range which is the most easterly spur of the Andes rises to a maximum of 940 m and is steeply dissected, the Central Range is steeply undulating and varies from about 60 m to a maximum of 308 m and the Southern Range is undulating with a large percentage of the area lying between 60 and 150 m.

5. Tobago consists of a central steeply dissected ridge rising to a maximum of 576 m and running in a North-East/South-West direction for 30 km. The Southern parts of the Island are relatively flat and the coastal plain is formed of coral terraces.

6. Geologically the rocks are almost entirely sedimentary in Trinidad while in Tobago, igneous rocks yield excellent soil cover over half the Island with sedimentary rocks and coral limestone forming the parent material elsewhere.

7. The total forest area of the country amounts to $2\,728\text{ km}^2$ of which $2\,184\text{ km}^2$ or 42.6% of the land area belongs to the State. Of the State-owned forests, $1\,267\text{ km}^2$ (24% of the total land area) have been legally constituted as Forest Reserves. Forest types have been mapped with the aid of aerial photography and found to be distributed as follows:

| | |
|--------------------------------|----------------------|
| Edaphic Swamp Forest | 164 km^2 |
| Montane Forest | 225 km^2 |
| Evergreen Seasonal Forest | $1\,152\text{ km}^2$ |
| Semi-evergreen Seasonal Forest | 141 km^2 |

| | |
|---------------------------------------|---------------------|
| Dry Evergreen Forest | 5 km ² |
| Deciduous Seasonal Forest | 37 km ² |
| Deflected Climax (Forest Plantations) | 214 km ² |
| Secondary Forest | 61 km ² |

8. The population numbered 1 067 000 inhabitants in 1974, the annual growth rate is 1% and the population density is 208 inhabitants per km².

9. In the years 1973 to 1977 the out-turn of saw-logs from the natural forests and plantations averaged 91 000 m³, the quantity of fuelwood harvested was insignificant and poles from the teak plantations averaged 1 400 m³/annum. In 1977 a total of 127 400 m³ of sawn timber was imported mainly from Honduras and the USA and the net cost of all forest based imports including paper amounted to \$ 115.6 million.

10. There are sixty-eight sawmills in Trinidad and Tobago, few are equipped with re-saws or planers, there are no veneer or paper mills in the country and the one particle board mill uses bagasse as the raw material.

11. In 1982 the activities of the Forest Division provided some 270 000 man days of work and in addition, 276 monthly paid staff were employed. Timber harvesting, sawmilling, etc. gave employment to some 2 000 workers in the private sector.

12. In 1977 the total revenue of the Forest Division amounted to \$ 1.26 million and expenditure including development of plantations to \$ 9.06 million.

1.2 Factors leading to Forest Reservation, the Promulgation of the Forest Laws, Forest Management and the Drafting of a Forest Policy

13. Trinidad became a British possession in 1797 and Tobago in 1802. The importance of the forest cover for the protection of the soil and water supplies was well understood by the French who earlier owned Tobago and who delineated the first Forest Reserve in the Western Hemisphere along the Main Ridge in Tobago in 1765. Later, in 1880, an enquiry into forest conservation and the maintenance of water supplies was begun and as a result of this, a tentative Forest Policy was formulated within the Report of the enquiry. The report identified three main headings under which conservation should be studied, viz. forests with reference to water supply and public health; forests with reference to the utilisation of forest produce and thirdly the re-forestation of denuded areas in public and private ownership.

14. As a result of the 1880 enquiry the Deputy Conservator of forests of the Indian Forest Service was invited to visit Trinidad in 1899 and submit a report on forest conservation. The report was laid before the Legislative Council in 1900 and dealt comprehensively with the principles of the conservation of soil, water and renewable natural resources. In identifying areas to be protected he explained that as far as possible these were restricted to poorer lands leaving the richer soils available for cultivation. In all he selected 653 km² for the protection of water supplies, 78 km² for fuel supplies and 28 km² for windbreaks. Thus, by the year 1900, 15% of the country had been identified as potential forest reserves. Treatment of the areas selected was discussed including steps to regulate the yield of produce, the rotation or cutting cycle within the forest and the effects of dry season fires. To implement the proposals it was suggested that a professional forest officer be recruited from the Indian Forest Service and that he should be assisted by two forest rangers and twenty-one forest guards. Initially, the work

should concentrate on the survey and demarcation of the forest reserves under the Crown Lands Office and later, when the forest estate is established, a Department of Forestry should be formed.

15. The professional officer (C.S. Rodgers) was appointed in 1901, reservation surveys began in 1902 and by 1908, 450 km of boundary lines had been surveyed and demarcated thus virtually completing the establishment of the forest estate as proposed in the report of 1900. The Forest Department was set up in 1918 and the reserves already surveyed were proclaimed in 1922 and from then until 1960 the legal constitution of additional reserves continued until the present area of 1 267 km² was reached.

16. In the earlier days of the century the rural population was heavily dependent upon the forests for fuel, poles and other minor forest produce. The main forest areas had few roads so timber exploitation was confined to extraction distances along the sides of the roads which existed and only such valuable species as Cedrela odorata, Manilkara bidentata, Tabebuia serratifolia, etc. were exploited. Sawing was done by pit-saw and heavy timbers, e.g. bridge runners were adzed. The bulk of sawn timber was imported from the USA and in 1899, \$ 200 000 worth of such timber entered the country. House building materials in rural areas, e.g. poles, laths, thatching, etc., came from the forest and wild game supplemented food supplies. With the discovery and exploitation of oil the use of fire-wood and charcoal declined progressively and by about 1960 kerosene and electricity had virtually displaced forest-based fuels from even remoter areas with significant effects on the silvicultural work of the Forest Department (See chapter 2).

17. With the establishment of the forest estate came the need to develop legislation under which forestry could operate. In 1915 a Forest Ordinance was enacted to provide the legal basis for the operation of forest officers, the sale of forest produce, the definition of forest offences and the stipulation of penalties, etc., and in 1919 the Crown Lands Forest Produce Rules detailed the procedures governing the sale of produce. The Sawmills Ordinance followed in 1943 and the Agricultural Fires Act in 1963 and earlier legislation has been amended as circumstances required.

18. Small-scale plantations were begun in 1908 using Cedrela odorata, Swietenia mahogani and Cordia alliodora. By 1912 some 56 ha of such plantations had been formed but in the following year most were destroyed by fires. Damage from a shoot-borer (later identified as H. grandella) was noted on the Meliaceae in 1910 and this has proved to be a pest of the Meliaceae on many lowland tropical areas throughout the world. Natural regeneration received attention in 1910 when 18 ha of exploited forest were under-brushed and vines cut to determine whether the area would regenerate naturally with a crop of economic value.

19. In 1926 an experimental plantation of Calophyllum brasiliense established on almost pure brown sand proved to be the inadvertent fore-runner of the Tropical Shelterwood System (TSS) of natural regeneration as practiced in Trinidad. It was noticed that as clean weeding of the plantations proceeded the plants became chlorotic and when a ground cover was allowed to persist the plants improved. Clean weeding was suspended and natural regeneration of economic species began to appear. Over the years to about 1940 the TSS evolved as follows:

- | | |
|---------|--|
| Phase 1 | Pure plantations |
| Phase 2 | Plantations supplemented by natural regeneration |
| Phase 3 | Natural regeneration supplemented by planting |
| Phase 4 | Natural regeneration only. |

20. In 1913 teak (Tectona grandis) seeds were obtained from Burma and sown in the Southern Watershed and at Mount Harris. Sowing at stake gave poor results but nursery raised plants attained up to 10 m in 2 years and 3 months. In 1915 teak plantations were established by the taungya system and as the annual area planted progressively increased the taungya areas became an important source of locally produced food in areas near to plantations. This system reached a peak in the early 1960's when over 300 ha were intensively cultivated each year under the taungya system.

21. To provide data for the management of the forests a 2% enumeration strip survey was commenced in 1928 and 92 000 ha were sampled in the following 10 years. Timber sales were made according to the value class and girth of the tree to be sold and when Working Plans were introduced in 1935 additional prescriptions were made to regulate the number of Class I trees which could be felled within working plan areas. For trees in Classes II to IV girth limits were progressively less demanding.

22. Over the years a Forest Policy evolved and in 1942 this was formally adopted by Government. The main elements of the policy can be summarized as follows:

- a) The reservation of an adequate forest estate to ensure the direct and indirect forest benefits for the community;
- b) The attainment of a sustained yield and self-sufficiency in timber supplies;
- c) The promotion of the wider use of timber and the conduct of research in tropical forestry;
- d) The provision of training for subordinate staff and the dissemination of forestry knowledge;
- e) The encouragement of private forestry and the cooperation with other agencies in promoting the wise use of land.

2. MANAGEMENT OF THE STATE-OWNED FORESTS

2.1 Salient Features of the Forest Law and Regulations

23. The Forest Policy summarized in the previous paragraph evolved gradually from the turn of the century and in 1915 a Forest Ordinance was enacted to provide the basis for the implementation of the embryonic Policy. The present Forest Act is the result of continuous revision of the original Forest Ordinance and amendments have been made on six occasions to keep it abreast of the requirements and development of the country. After definition of the terms used, the Act stipulates the general conditions for the cutting and removal of forest produce, detailed conditions being subject to separate Rules and Regulations made by the appropriate Minister and published from time to time. The Act then describes forest offences, e.g. cutting or removal of produce without written authority, etc.; gives power of arrest to Forest Officers if offences have been committed, gives authority to certain grades of Forest Officers to compound offences (i.e. impose penalties under strictly defined conditions if the offender is prepared to accept the penalties rather than appear before a magistrate); gives power to Forest Officers to demand production of written authority to remove forest produce and the power to seize tools, vehicles, etc. used in the commission of a forest offence.

24. The Forest Produce Rules are those regulations made under the Forest Act by the Minister in whose portofolio Forestry is included. These Rules define the conditions under which licenses for timber and other forest produce may be issued by Forest Officers, the procedures for marking and measuring trees before felling, the measurement and release of felled timber and the stumpage fees to be charged. The Rules also provide for the Conservator of Forests to vary stumpage fees if it is desirable to dispose of produce for silvicultural reasons.

2.2 The Timber Licensing System

25. In view of the high population density ($208/\text{km}^2$) and the inability of the natural forest and plantations to satisfy the demand for forest-based products there is a strong demand for timber cutting licenses. As roads through forest areas were opened up many rural dwellers began to cut timber for sale to sawmills and as the practice increased the demand in certain areas exceeded the supply of timber available. This situation reached critical proportions in the early 1950's in the gregarious mora (Mora excelsa) forests of the North-East and rationing of licenses had to be introduced. This system has spread to several other areas and even where rationing is not applied on an annual basis of some 20 m^3 per licensee, licenses for ten trees only are granted with only two licenses being worked concurrently by any one licensee. Thus, the basis for timber working is the fair distribution of a scarce resource among the rural population (and in some cases, sawmill owners) and large or long-term timber concessions are not granted in Trinidad. Undoubtedly the system is cumbersome but it is the only system which ensures that the rural and forest-based populations have first priority in the allocation of the relatively small quantities of timber available.

26. Within teak plantations a concession has been granted to a Government-owned company to extract, process and market thinnings and final fellings from the plantations but this is a very different matter from the grant of concessions to privately owned companies to exploit the natural forest.

2.3 Working Plans

27. Working plans were first drawn up in the mid 1930's and the objects were to attain a sustained yield through control by area or by girth limits and to regenerate intensively worked areas by natural or artificial means. The earlier working plans followed the layout and content of the plans used in the Indian Forest Service which were themselves adaptations of the classical form of plan used in Germany and France. The first working plans in Trinidad tended to be particularly detailed in Part I and much shorter in Part II (the prescriptions) for which detailed knowledge was not then available. The contents of Part I included information concerning: situation, area, ownership, boundaries, geology and soils, climate, legal position and rights of the local population, markets and prices of produce, history and description of the growing stock, injuries to which the crop was liable, silvicultural characteristics of the species, organisation and staff.

Part II laid down the following: the period for which the Plan would operate, the objects of management, division of the area into control units, methods of controlling the yield (by area, girth limits, etc.), forecast of the yield and a programme of silvicultural activities.

Records were to be kept of the annual yield and value of all produce harvested, a compartment history was to be compiled for all work done within compartments during the period of the plan and a record and cost of all other work done (road construction, repairs to buildings, etc.). Any deficiencies occurring in Part II as a result of information not then being available was, to some extent, compensated for by the prescription that a Programme of Work would be drafted annually within the framework of the general prescriptions of the Working Plan.

28. As the areas under Working Plans increased and the numbers of professional staff failed to increase proportionally, Plans became simpler and were typified by the 1953 Plan for the Melajo Forest Reserve. Part I of the Plan was greatly reduced in detailed content and Part II prescribed yield control by area and became little more than a map showing the annual coupes for the period of the Plan. The annual programme became the main prescriptive document although the programme continued to conform with the objects of management laid down in the Plan. In 1959, it was calculated that the maximum area of soils suitable for teak amounted to about 16 800 ha and based upon a rotation period of 60 years, annual programmes limited the total annual area to be planted under teak to a maximum of 280 ha/year until such time as future refinement or re-assessment of soil and site data gave cause to revise this limit. Staff shortages and an expanded area of responsibility for the Forest Authority continued until recent times but now that staff numbers are more favourable and a country-wide forest inventory has been completed newer concepts of working plans are being considered. This is dealt with in chapter 4 below.

2.4 Management of Forests placed under Systems of Natural Regeneration

29. As shown above, the Trinidad version of the TSS evolved from plantations commenced in 1926 at Arena Forest Reserve. The topography of the Reserve is gently undulating, the elevation varies from 30 to 60 m and the drainage is generally good. Much of the soil is of whitish to brown sand of low nutrient status which deteriorates further when exposed. The average rainfall is 2 400 mm per annum and the temperature within the forest varies from a maximum of 27.7°C to a minimum of 19°C. The vegetation is tropical evergreen rain forest of the Carapa-Eschweilera type with a three-layer structure of emergents, a continuous canopy and a lower storey of some 3 m to 10 m height. Over-cutting of the durable hardwoods, e.g. Manilkara bidentata, Eschweilera subglandulosa, Tabebuia serratifolia, etc., has been severe.

30. During the period 1927-1931, management consisted of clear-felling an annual regeneration area of varying sizes selling the timber felled and planting with Carapa guianensis and Calophyllum brasiliense. Parts of the area were burned before planting and the remainder was left unburned. The system was abandoned because of high cleaning costs and the soil deterioration reflected in the chlorotic nature of the regeneration. There was also widespread attack on the Carapa of the shoot-borer, Hypsipyla grandella.

31. From 1932 onwards, timber felling and the activity of charcoal-burners were so regulated that at the end of exploitation a shelterwood of dominants was left standing. The following rules were laid down for shelterwood formation:

- (i) Cut vines 2 years in advance of shelterwood formation;
- (ii) Leave, as far as possible, dominants of marketable species and remove only such dominants and sub-dominants as will cause too much shade even after removing the under-storey;
- (iii) Mark for felling all trees of the lower storey except where dominants or sub-dominants are absent;
- (iv) If it is then desirable to remove additional dominants such trees must be poisoned and not felled to avoid damaging the adjoining shelterwood;
- (v) Fell and palms.

32. Felled trees of marketable species were hauled to the roadside by bulls and all other felled trees suitable for manufacture into charcoal were converted in situ using earth covered "pits" (actually tightly packed short lengths of logs and branchwood stacked above ground and covered with soil). The average size of each pit was about 103 m³.

33. The regeneration was cleaned from the 2nd to the 7th year and, where necessary, supplemented by planting. When increased light became necessary for continued growth the shelterwood was progressively removed by poisoning (sodium arsenite in aqueous solution of 100 g to 1 litre) over a period of 10-12 years and thinning of the new crop was undertaken when this appeared silviculturally necessary.

34. The Area Reserve Working Plan for the period 1936-1945 prescribed annual coupes of 25 ha on a sustained yield rotational basis of 60 years. The quantity of useful regeneration exceeded expectations and a decision was made to expand the annual coupe even although this conflicted with selected rotation of 60 years. This was encouraged by a change in market conditions which, partly as a result of reduced timber imports during the war, allowed the marketing of some fast-growing species and as the number of acceptable species increased so confidence in a shorter rotation (and hence a larger annual coupe) became established. In 1944 the annual coupe was increased to 40 ha and in 1950 this increased again to 68 ha. Up to 1946, annual coupes were distributed as widely in the Reserve as accessibility would allow in order to minimize possible effects from exposure but this precaution proved unnecessary and to simplify management, annual coupes were formed contiguously from 1947 onwards.

35. Regeneration counts indicated that there was no apparent relationship between the species regenerating and those composing the shelterwood and since few species regenerating under the TSS in Trinidad have winged seed the inference was that the regeneration came from seed already on the ground at the time of shelterwood formation and that a number of species was introduced by fruit eating bats and birds. As the market acceptance of fast-growing species continued it became obvious about the mid-1950's that what was needed was a felling cycle of about 30 years rather than the original rotation of 60 years. Under such a system, fast-growing species, e.g. Didymopanax morototoni, Byrsonima spicata, Sterculia caribaea, etc. would be cut at the end of the first thirty years leaving the slower growing traditional timbers as a shelterwood for a second generation of fast-growing species. At the end of the second cycle the crop would then be composed of "first generation" slower growing timbers and "second generation" fast-growing species.

36. The effect of the change to polycyclic system on the method of shelterwood formation was profound. Dominants were no longer retained for the shelterwood since satisfactory regeneration could be obtained from pole-size trees providing perching places for birds and roosts for bats. Such pole-size trees were much preferred since they would remain sound for the 30-year cycle, all dominants could be harvested and the cost of later poisoning reduced or eliminated. Weeding costs were also reduced since the aggressively growing seedlings of the secondary species then becoming marketable could be left as a nurse crop for the slower growing, more shade tolerant traditional hardwoods.

37. The sequence of operations from the mid-1950's became established as: (r = year of regeneration)

| | |
|-------------------|---|
| r - 2 | Vines cut |
| r - $\frac{1}{2}$ | Mature timber exploited |
| r | Shelterwood formed. Charcoal-burners operate in coupe |
| r + 1 | Clean weeding to ground level. Woody growth of non-economic species retained (to discourage grass) unless interfering with valuable species |
| r + 2 | As for r + 1 but weeding not done to ground level |
| r + 3 | Vines cut. Non-economic woody growth reduced |
| r + 4 | Vines cut. Woody growth reduced. Any shelterwood not to form part of new crop poisoned |
| r + 5 | Thin regeneration as required |

Supplementary planting was again introduced in the 1950's but on this occasion the object was to introduce species (mainly exotic) not present in the original forest rather than to obtain full stocking. Species planted included Simarouba amara, Chlorophora excelsa, Nauclea diderrichii, Terminalia superba and T. ivorensis. It is interesting to note that S. amara now appears (1983) in areas of regeneration far removed from the original introduction.

38. Dramatic changes in silvicultural costs accompanied the changed technique. The average silvicultural costs for the first 5-year period in the 1940-1942 coupes were 128 man days per ha and those of the 1950-1952 coupes 26.5 man days per ha. A study of costs in 1957 revealed that the silvicultural costs throughout a 30-year cycle would amount to 60 man days per ha and increment studies suggested that an average of 5 m³/ha/annum would be obtained.

39. As standards of living improved in Trinidad, charcoal was replaced as a fuel by kerosene and electricity and coal-burners progressively deserted the work. At Mount Harris in 1953 where coal-burners were not available the Arena technique was adapted as shown below. Following upon timber exploitation a shelterwood was formed by:

- (i) under-brushing the area;
- (ii) Cutting all undesirable trees up to a diameter of 15 cm;
- (iii) Marking 70-80 pole-size trees per ha of desirable species (if available) for retention as shelterwood and poisoning the remainder.

Cleaning and weeding were carried out as described above for Arena and in 1957 the annual report stated that results were comparable with those at Arena but that the additional cost of shelterwood formation amounted to 26 man days/ha. In other parts of Mount Harris where the forest had been badly depleted direct sowing along lines cut at 6 m intervals was used to supplement regeneration and this method is now known as the Mixed Conversion System and is used on a limited scale.

40. In the North-East Melajo (Mora excelsa) forests, exploitation was confined to annual coupes and intensive charcoal operations, following timber exploitation, created a good shelterwood cover. No follow-up silvicultural operations took place yet a satisfactory new crop of mixed species became established through the agency of seed dispersal by bats and birds. At that time, there was great pressure for exploitation at a much faster rate than good management dictated and this was a prime factor in the frequency with which dry season fires occurred, the logic being that fire-damaged trees, outside annual coupes would then be sold to licensees. These fires did not, however, confine themselves to areas to be exploited in future years but spread to previously exploited coupes thus wiping out the regeneration. The soil of the Mora forests is almost pure quartzite sand and gravel and once the surface humus layer has been destroyed by fire, natural regeneration cannot be re-established in a reasonable period of time. The situation became so difficult that a decision was made to plant up as much of the area as possible with Pinus caribaea, happily with very satisfactory results. A further extension of area control of the yield has more recently been introduced to areas in the South of Trinidad. No post-exploitation cleanings are undertaken.

2.5 Management of Forests placed under Systems of Artificial Regeneration

2.5.1 Regeneration with Teak (Tectona grandis)

41. Teak plantations are formed at a number of locations in Trinidad and the preferred soil is a well-drained clay loam of pH 5.5 to 6.2. The areas are generally undulating and rainfall varies from 1 500 mm/annum to 2 500 mm/annum. A marked dry season is required for successful growth.

42. As stated in paragraph 18, some 56 ha of experimental plantations were destroyed by fire in 1913 but from this misfortune, important lessons were learned. The first was that plantations in Trinidad will always be subject to fire risk in the dry season, the second was that unless felling debris is burned before planting, a fire when it occurs will be more damaging than otherwise and the third lesson is one which has been consistently ignored in most (but not all) lowland tropical areas when commencing plantations that is the effect of the shoot-borer Hypsipyla on the Meliaceae when species of this family are used to form plantations. Whatever species was chosen for plantation work in Trinidad it had to have some degree of resistance to fire damage and teak was the species chosen. Until recent times it was the species on which the main plantation effort was centred.

43. Trinidad was fortunate that the original importation of seed from Tenasserim in 1913 flourished under local conditions. Additional imports of seed were made from the same source in 1915 and 1916 but germination from these batches was poor. The plantations of Trinidad are therefore virtually derived from the 1913 importation although a small amount was obtained from India in 1934 for experimental purposes. No seed collections are made from the area derived from the Indian seed because of the poorer form and growth compared with the Tenasserim strain.

44. From 1918 onwards plantations were formed from seed produced by the 1913 importation. What was not realised at that time was that the early flowering and seeding of these very young trees were genetic characteristics of the individuals and that the early terminal flowering causes bifurcation of the main stem to take place. Thus, in the early years what happened was, in effect, a positive selection for the production of short-boled trees because of the genetic character controlling flowering. Even today the plantations of the 1920's have frequently poor form and for many years this was believed to be due to the wider spacing (up to 3.5 m x 3.5 m) at which the plantations were formed. The inferiority of the early locally produced seed now seems a more likely reason.

45. The genetic quality of seed improved gradually as thinnings eliminated badly formed trees and in 1960 seed stands were designated after close examination of all stands of 25 years or over. By that age a well-thinned compartment has been reduced from the original 2 500/ha to some 200-250/ha and only trees of good form remain. Thus, the genetic quality of seed from the seed stands of Trinidad is now high.

46. Agro-silviculture flourished in Trinidad for many years as part of the management system for cocoa plantations. Plantation owners leased plots of land for several years to agricultural workers who cleared the forest, planted cocoa and used the area for their own food crops during the period of the lease, moving on to new areas when the cocoa was established and receiving some payment for the work done. This system bore similarities to the taungya system under which teak plantations were formed in Burma and was readily adapted to teak planting in Trinidad, the main differences being that the lease was for one growing season (15 months to allow for felling, burning, planting and reaping) only and that no payment was made. However, the Forest Department was responsible for fire-tracing, burning and planting and the taungya farmer had a fresh piece of land for his crops each year.

47. Working Plans were drawn up for reserves in which teak plantations were to be formed. Generally the reserve was divided into an Exploitation Working Circle in which the yield was controlled by girth limits and a Teak Conversion Working Circle in which the natural forest would be converted to teak during a 60-year rotation. Since the funds available for planting were not assured several years in advance it was prescribed that the Conversion Working Circle would be expanded annually at the expense of the area of the Exploitation Working Circle. When planting was to take place at two or more centres, the Working Circle was divided into the appropriate number of felling series, the management unit within which the compartment was.

48. To encourage maximum exploitation of compartments before conversion, girth limits were removed 18 months before planting. A site for a "flying" nursery was also chosen. The nursery site was clear-felled and burned in the dry season of the year before planting (1 ha of nursery for 40 ha of plantation to be formed) and nursery beds two-metres wide formed between contour drains of 25 cm depth. With the coming of the rains the beds were sown at a spacing of 15 cm x 15 cm. Germination was generally good, the beds were weeded after two months and seedlings thinned to one plant per planting spot. (Teak "seed" are botanically fruits and contain up to four seeds).

49. In the following dry season the remainder of the compartment was under-brushed and felled by the taungya farmers then fire-traced and burned by departmental labour. At the start of the wet season the nursery plants were lifted, "stumped" and planted out at a spacing of approximately 2 m x 2 m by opening a hole in the soil with a sharp-pointed bar, pushing in the stumps to the level of the "collar" then firming the soil around the stumps. The taungya farmers whose areas averaged 0.4 ha kept the teak weeded during the first year, reaped their crops and moved on at the end of the year.

50. Cleaning of the teak was carried out once or twice in the second year and generally once in the third year. Thinning commenced in the 5th year and the schedule for many years was:

| | |
|---------|-------------------------|
| Year 5 | Reduce teak to 1 250/ha |
| Year 10 | Reduce teak to 625/ha |
| Year 15 | Reduce teak to 310/ha. |

Five yearly thinnings continued until the 30th year, the aim being to form an evenly distributed crop with adequate space for crown development for each 5-year period. Beyond the age of 30 years the frequency of thinning depended on the vigour of the crop and indications suggested that on good quality sites the stocking at rotation age would be about 75-90 trees/ha depending on vigour.

51. The prescriptions in the annual programmes included such items as fire protection, maintenance of amenity strips along roadsides, maintenance of offices, buildings and tools, the purchase of materials, the extension of roads, etc. An annual programme (a synthesis for illustration only) would appear as in Table 1 and information would also be included concerning Expenditure Heads against which the several types of work would be charged.

52. Sample plots were first laid out in the mid 1920's and new plots have been regularly added. Probably the plots have been sited on areas of slightly better than average growth but they provide a good indication of growth over the years. The records of these plots were used between 1966 and 1969 to form provisional yield tables and the information below is derived from this source.

Table 1

Annual Programme for the Year 1963

Working Plan: Central Range Reserve

Working Circle: Teak Conversion FELLING SERIES Mount Harris

| <u>Coupe</u> | <u>Compartment</u> | <u>Net Area</u> (ha) | <u>Prescription</u> | <u>Rate</u> \$ | <u>Cost</u> \$ |
|-------------------|--------------------|-------------------------|---|-------------------|-------------------|
| 1955 | 13 | 25 | No work | - | - |
| 1956 | 14 | 25 | No work | - | - |
| 1957 | 15 | 28 | Mark thinnings | 18 | 504 |
| 1958 | 16 | 30 | Fell thinnings | 22 | 660 |
| 1959 | 17 | 35 | No work | - | - |
| 1960 | 18 | 40 | Weed teak | 30 | 1 200 |
| 1961 | 19 | 40 | Weed teak | 35 | 1 400 |
| 1962 | 20 | 40 | Weed late in year | 40 | 1 600 |
| 1963 | 21 | 40 | Fire-trace and burn. Lift teak stumps and plant at 2.5 m x 2.5 m | 50 | 2 000 |
| 1964 | 22 | 45 | Survey compartment, locate nursery, clear-fell and burn, form seed beds, sow seed and weed in September | - | 3 000 |
| <u>Other work</u> | | (i) | Fire protection in plantations | | 2 000 |
| | | (ii) | Purchase and maintenance of tools | | 1 000 |
| | | (iii) | Maintenance of buildings | | 2 500 |
| <u>Roads</u> | | (i) | Cutlass and maintain inspection paths | | 600 |
| | | (ii) | Maintain plantation road | | 2 000 |
| | | (iii) | Extend plantation road by 500 m | | 4 500 |
| | | | | Total | 22 964 |

53. Figure 1 shows the height-age curves into which the investigation divided the crop and from these it is clear that from about the 30th year the height growth flattens rapidly. The total volume of the crop, including thinnings is shown at Figure 2 and the Mean Annual Increments at Figure 3. The results shown by Figures 1 to 3 are now wholly indicative of the crop. The more favourable positions of sample plots has already been mentioned and in recent years thinnings have fallen behind schedule although the sample plots have been thinned and measured. Thus, it appears that the sample plot results over-estimate the volumes of the surrounding compartments and this excess is probably in the region of 10-15%.

54. The cost of daily paid labour has increased from about \$ 2.30 per day in 1950 to about \$ 80.00 in 1982 including miscellaneous payments, e.g. tool allowance, etc. The average present cost of establishing teak plantations (in man days/ha) is shown in Table 2. The establishment period is taken as the first 5 years plus nursery costs incurred in the year prior to planting. The year of planting is represented by the symbol P. Increasingly there has been a shortage of taungya farmers to undertake this form of agro-silviculture and Table 2 has therefore been drawn up to reflect the situation in which all work is done by the Forest Department. Where taungya farmers are available a subsidy of \$ 120/ha is paid as compensation for work done within the area.

Table 2
Average Costs (man days/ha of plantations) of Establishing
Teak Plantations

(Year of planting = P)

| <u>Year</u> | <u>Work done</u> | <u>Costs</u> (man days) |
|--------------|--|----------------------------|
| P - 1 | Under-brush nursery area, clear-fell, fire-trace and burn. Dig drains, form beds, sow at 15 cm x 15 cm. Weed plants and remove "doubles" | 15 |
| P | Under-brush, clear-fell, fire-trace and burn | 22 |
| | Lift nursery plants and form "stumps" | 3 |
| | Plant stumps | 8 |
| | Weed and replant blanks in September | 12 |
| P + 1 | Weed plants | 12 |
| P + 2 | Weed plants | 12 |
| P + 3 | Weed plants | 7 |
| | Mark for thinning | 4 |
| P + 4 | Thin crop | 5 |
| Total | | 100 |

Figure 1

Teak in Trinidad

Height - Age

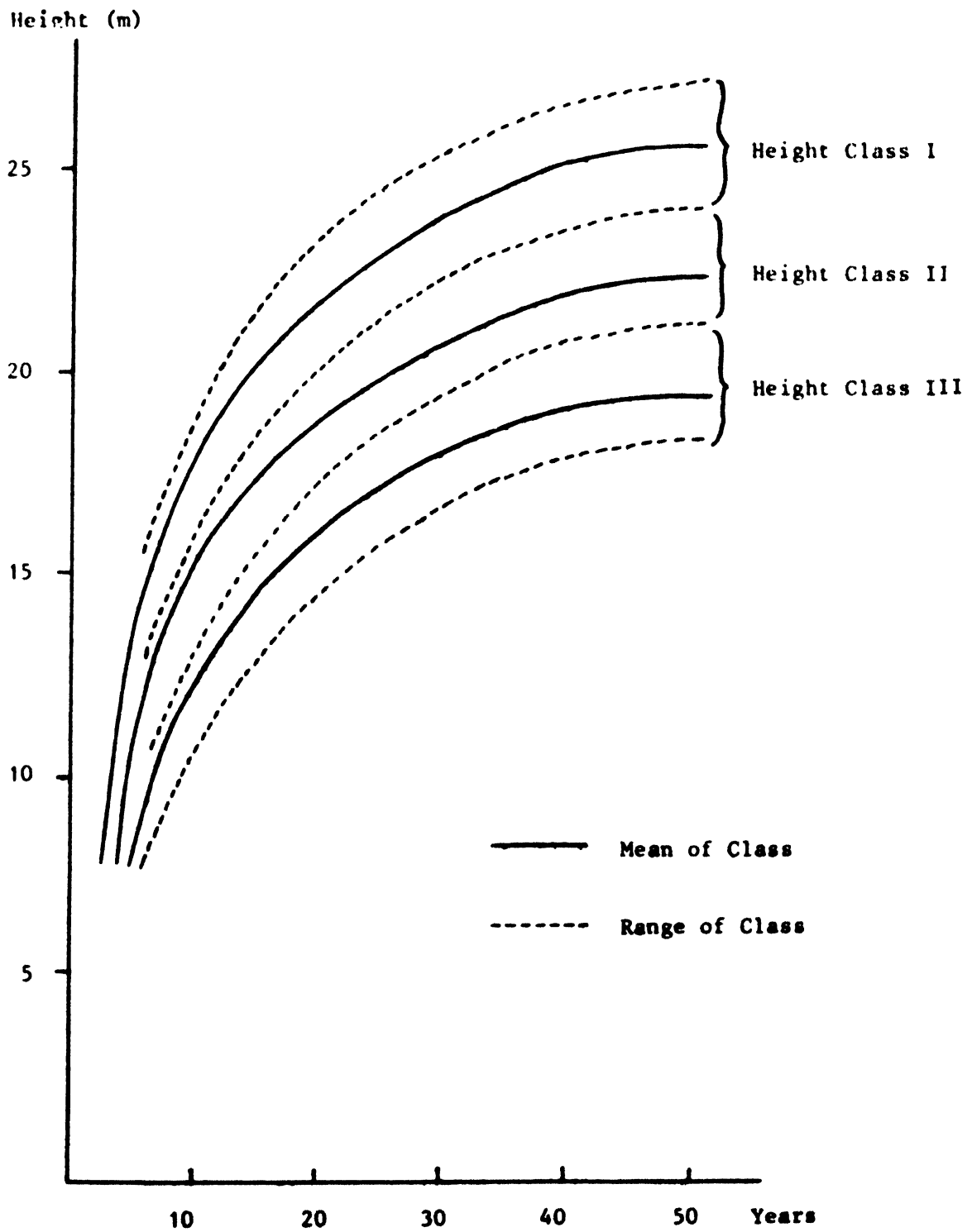


Figure 2

Teak in Trinidad

Total Volume-Age

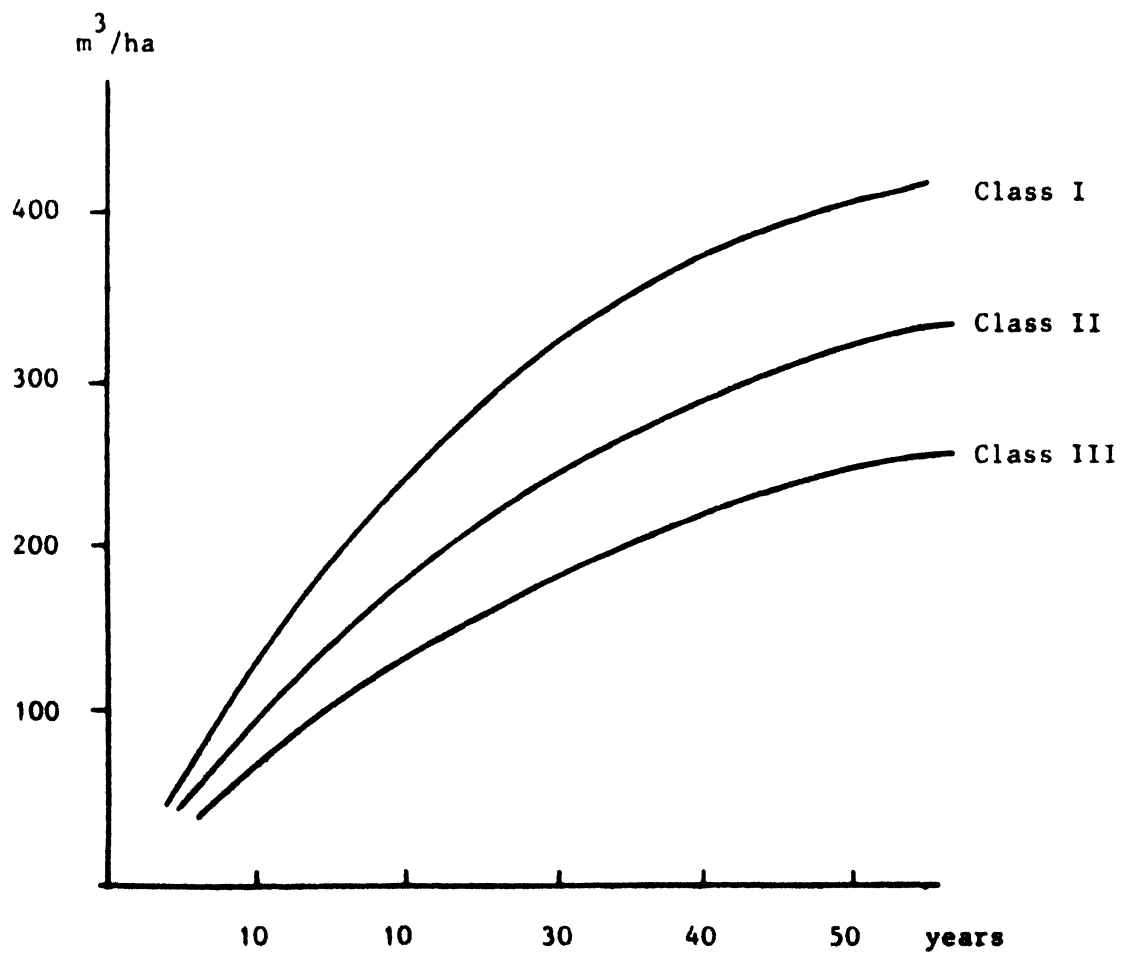
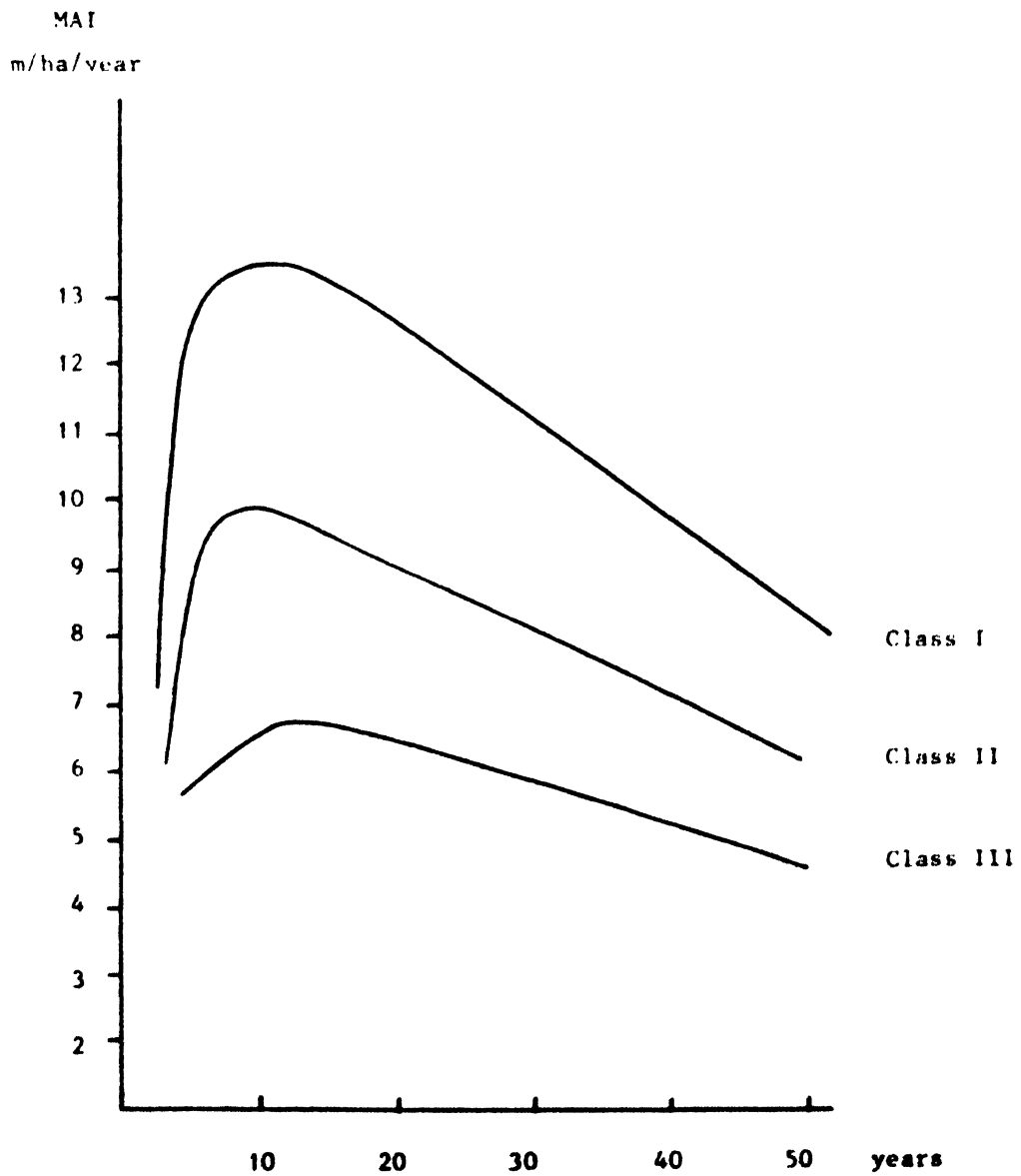


Figure 3

Teak in Trinidad

Mean Annual Increment-Age



55. Prior to 1976 teak thinnings were extracted, processed and marketed by the Forest Division. Split fencing was manufactured in 8 m rolls and in heights of 90 cm, 1.35 m and 1.8 m from 5-year old thinnings. The 10 and 15-year old thinnings were cut into round wood fence posts and treated with creosote by the "hot and cold" process. Thinnings of 15 years and upwards were cut on a log-edger type of saw in the Forest Divisions sawmill at Brickfield. The log-edger was used to produce scantlings of various sizes by boxing the heart (which in teak contains a wide pith) and the slabs were re-sawn into flooring strips and boards. The operation was profitable, a net profit of \$ 27 061 being made in 1961 on a gross expenditure of \$ 140 078 and additional employment being created in the surrounding rural area.

56. In 1976 a Government-owned company (Tanteak) was set up to fell, extract, process and market thinnings. Although new buildings were erected and more sophisticated machinery installed there is much less enthusiasm for processing the 5, 10 and 15 year thinnings and posts are not now creosoted although a market exists for these. A number of compartments have remained unthinned and from the silvicultural viewpoint some new arrangement must be made if thinnings are to be done at the proper time. Failure to do this in teak results in the buds on the branches being covered with callus tissue and unable to respond for several years to any subsequent thinning even at the relatively early age of 15 to 20 years.

57. Forest research was sporadic over the years but in the 1950's the post of research officer was created and in the early 1960's, thinning experiments, tree breeding and spacing trials were commenced. Because of staff shortages only the thinning experiments (in which five grades of thinning replicated five times) have survived.

2.5.2 Regeneration with Pine (*Pinus caribaea* var. *hondurensis*)

58. Pine was first raised in Trinidad in 1948, experiments on nursery and plantation techniques began in 1950 and the first routine plantations were formed in 1956. Available information and experimental plots showed that the best growth was obtained on sandy soils with a pH in the range 4.8 to 5.5 but reasonably good growth was also obtained on silts and on quartzite sands and gravels. All forest reserves in Trinidad have a suitable rainfall pattern and the pine has grown well in areas of 1 500 mm to 2 600 mm annual precipitation. Topography does not seem to have a discernible influence on results and growth on sites varying from flat to steeply sloping has been good. Areas planted are all below 300 m elevation. It became quickly obvious that the species was strongly fire-resistant especially after the age of four years which, as shown in paragraph 42, is a factor of great importance given the frequency of dry season fires in Trinidad.

59. Planting of pine is not yet done under formal working plan control and plantations are formed as fast as funds will permit, there being large areas of degraded forest available and suitable for conversion to pine plantations. Control of all work involved in establishment and maintenance of the plantations is effected through annual programmes drawn up for each plantation centre.

60. In the nursery, seed are broadcast in germination boxes filled with medium grade sand and germination takes place in about 5 days. Seedlings are transplanted into 7.5 cm diameter black polyethylene bags filled with a topsoil mix to which 10% mycorrhizal soil has been added. The transplants are hardened-off under sarlon netting during a two-week period, the netting is then removed and watering and weeding carried out as necessary. Sowing commences in October of the year prior to planting and is continued as necessary until about February and the ideal product is a plant of about 23 cm with a high root to shoot ratio.

61. Site preparation is similar to that for teak, i.e. merchantable timber is sold in the year prior to planting, the area under-brushed, clear-felled, fire-traced then burned towards the end of the dry season. Planting is carried out at 2.5 m x 2.5 m spacing and weeding carried out as required. The annual programme is similar to that shown above for teak plantations at Table 1 and the cost in man days/ha up to the end of the first 5 years is shown at Table 3.

Table 3
Average Cost (man days/ha of plantations) of Establishing
Pine Plantations

(P = year of planting)

| <u>Year</u> | <u>Item</u> | <u>Man days/ha</u> |
|--------------|--|--------------------|
| P | Under-brush, clear-fell, fire-trace and burn | 22 |
| | Cost of plants | 5 |
| | Planting pine | 11 |
| | Weed and supply blanks | 15 |
| P + 1 | Weed | 15 |
| P + 2 | Weed | 15 |
| P + 3 | Weed | 12 |
| P + 4 | Weed | 12 |
| Total | | 134 |

62. Data concerning growth rates are sparse but twelve permanent sample plots have been laid down and measurements made at regular intervals. Height-age classes have been identified and are shown at Figure 4, mean annual increments for these classes are shown at Figure 5 and it will be noted that at age 20, the mean annual increments of the classes have not reached peaks. At age 20 the mean annual increments vary from a low of 11 m³/ha to a high of 18 m³/ha. Thinning schedules are still under discussion with the question of an assured market for the thinnings being a problem still to be solved.

63. Apart from sample plot measurements, research work relating to pines has concentrated on tree improvement and the initial work which began in 1959 was concerned with the selection of "plus" trees. The criteria applied were:

- a) Stem form (straight and unforked);
- b) Vigour;
- c) Branching habit (light regular branching with a wide branch angle);
- d) Good seed production.

The danger of selection from immature stock and from plantations extending to only 200 ha was recognized but the aim was to perfect techniques as early as possible and to continuously extend the selection. Cuttings, air-layering and various types of grafting were employed to provide material for a clonal garden which was established with replicates of clones of 18 trees. In 1968 a seed orchard was commenced and grafting of stock plants continued until 1972 when 584 ramets had been established.

Figure 4

P. caribaea in Trinidad

Provisional Height Classes

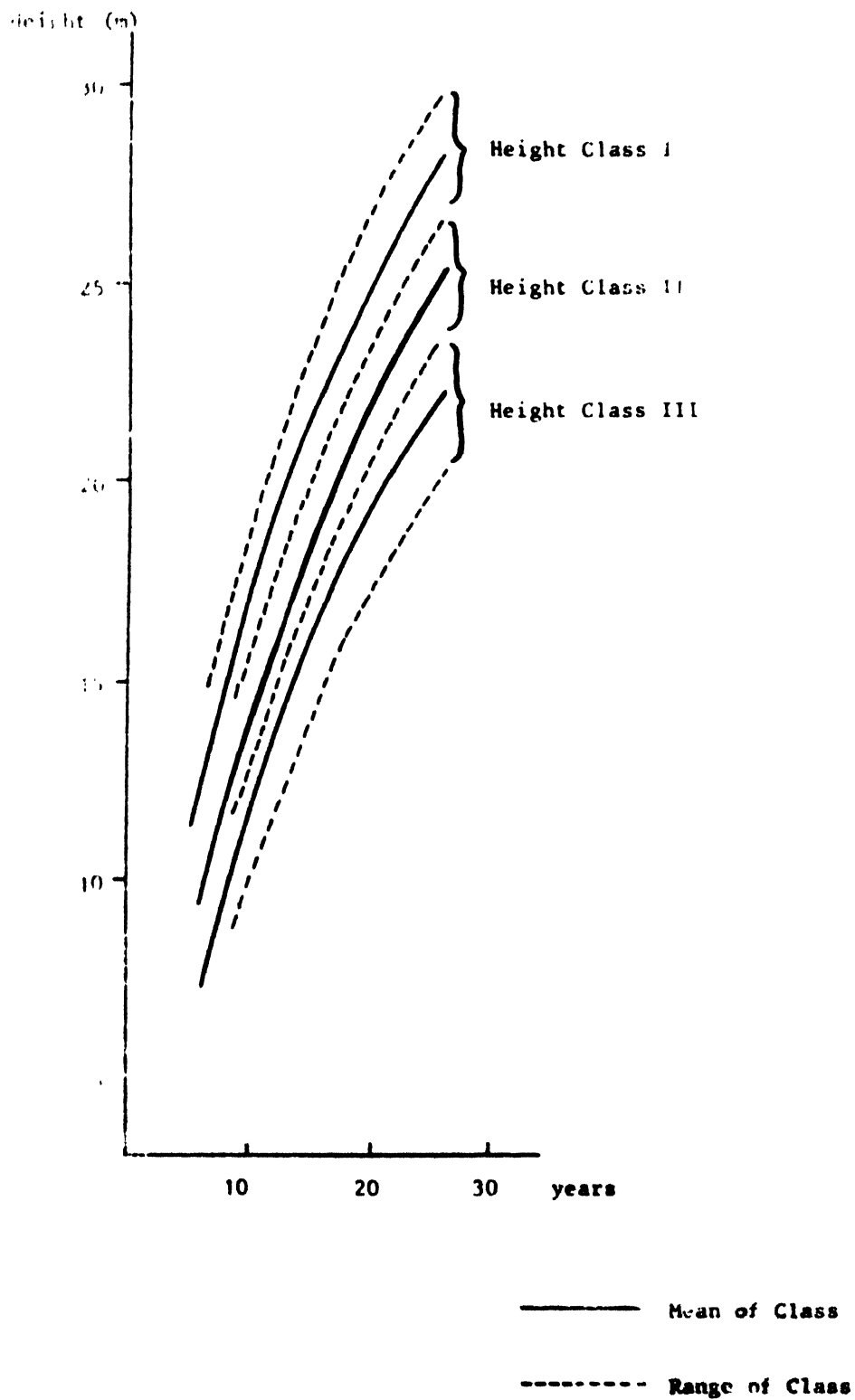
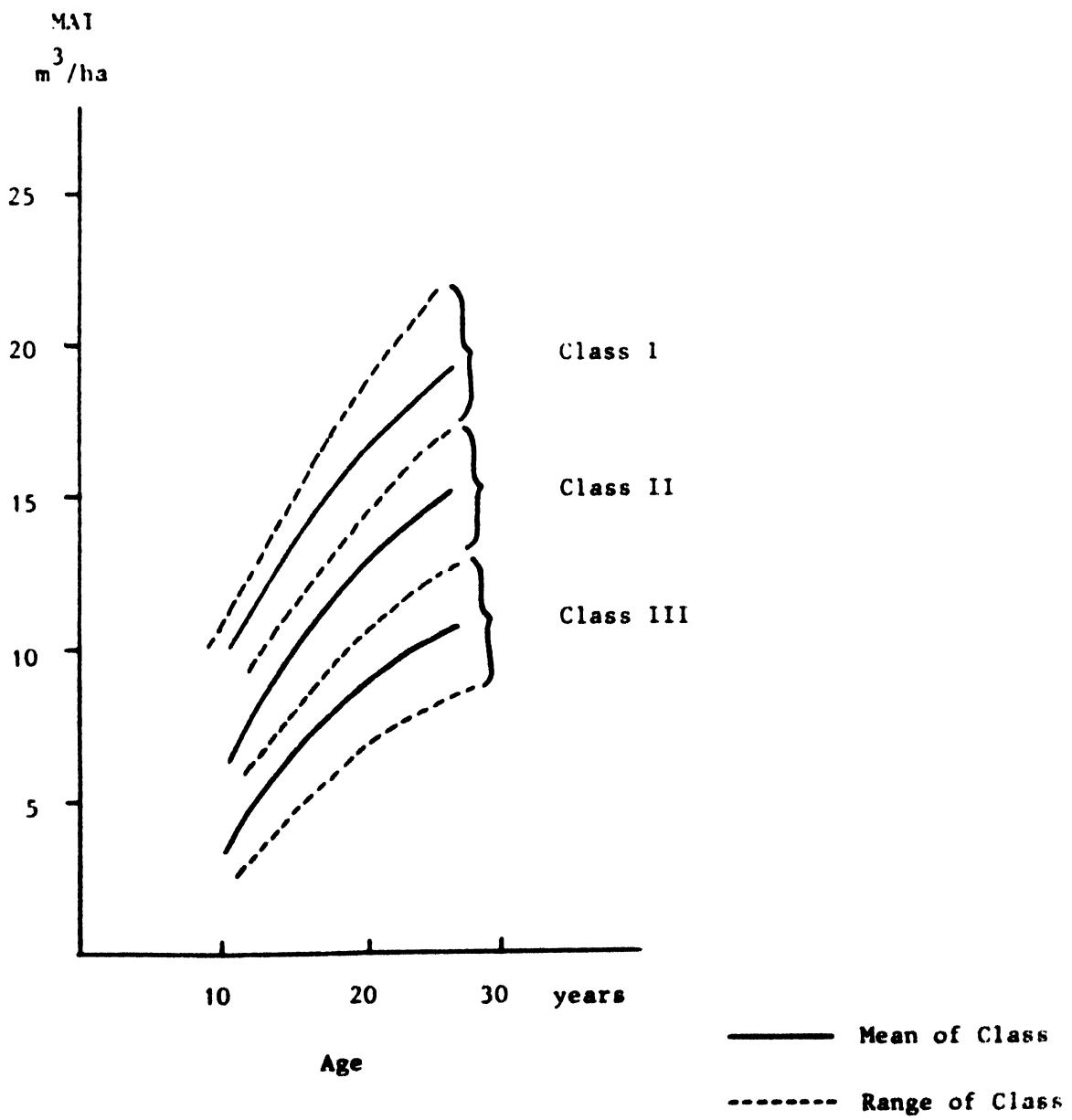


Figure 5

P. caribaea in Trinidad

Mean Annual Increment-Age



2.6 Watershed Management

64. The 1900 Report on Forestry (paragraph 14) drew attention to the severe soil erosion along the Northern Range and the effects of this on perennial water supplies. Not until 1972 was it possible to launch a scheme for soil rehabilitation although, when funds permitted, small-scale pilot plantations were established in critical areas. In 1972 the Northern Range Reforestation Project was launched as the start to the rehabilitation of some 24 300 ha of denuded or partly denuded lands on the slopes of the Northern Range. Of the total area to be treated, 16 200 ha lying above the 200 m contour will be reforested while the remaining area will be placed under agricultural crops. Up to the year 1980 some 1 900 ha had been treated and the most successful species has proved to be Pinus caribaea planted in lines cut along the contours. Whatever natural vegetation exists is left undisturbed between the lines.

2.7 Area Regenerated

65. The areas regenerated up to the end of 1977 amounted to 29 572 ha distributed as follows:

| | |
|--|-----------|
| Areas under natural regeneration systems | 13 984 ha |
| Areas under teak plantations | 9 327 ha |
| Areas under pine plantations | 4 785 ha |
| Areas planted or sown with mixed hardwoods | 1 476 ha |
| Total | 29 572 ha |

The area regenerated to the end of 1982 totalled 33 000 ha.

2.8 Forest Inventory

66. Between 1978 and 1980 a National Forest Inventory was completed with the assistance of Canadian bi-lateral aid. At the beginning of 1982 the final report of this Project was about to be published. The results will provide the basis for a long-term re-assessment of forest management and a stimulus for the formulation of new working plans based upon a much more intimate knowledge of available volumes than had existed in the past.

2.9 National Parks and Management of Wildlife

67. These topics fall more naturally within management of the forest estate rather than forest management in the accepted sense but they are mentioned briefly here since, because of the high population density in Trinidad, forests play a multi-purpose role in which a balance must be struck between the need for forest products and the provision of social and recreational benefits.

68. A National Parks Policy has been prepared and fifty-eight locations identified as areas of scientific interest, natural landmarks, scenic landscapes or areas suitable for nature conservation, national parks or recreation. Management and development plans have been drawn up for five of the areas and field work commenced. It is recognized that the development of all fifty-eight sites represents a long-term plan which will be implemented as funds become available.

69. The connection between forestry and wildlife protection has long been recognized and under the Wild Animals and Birds Protection Ordinance of 1934 the Conservator of Forests also became Chief Game Warden. Sanctuaries for wild birds and animals have been formed and protection given to endangered species. For those animals which may be hunted, "close" seasons are prescribed and the provisions of the Ordinance enforced by the staff of the Game Section of the Forest Division.

3. EVALUATION OF PRESENT FOREST MANAGEMENT

3.1 Technical Aspects of Forest Management

3.1.1 Working Plans

70. In most cases existing working plans have become obsolete and control is exercised through annual programmes. These permit established techniques to be applied but, with greater emphasis on integrating the forests into the life of the community through the development of National Parks and Recreation Areas. The need for new forms of working plans to guide and control the management of forests having a multi-purpose role has become apparent.

3.1.2 Exploitation Control by Girth Limits

71. Management by girth limits is increasingly being replaced by a block system in which exploitation is confined to annual coupes. Control by girth limits continues, however, to be useful in areas of steep slope or where the forest is too small to support intensive exploitation on a cutting cycle of, say, thirty years. The girth limits for each species and the stumpage value of classes I to IV to which the species have been allocated have become stabilized and are unlikely to alter significantly.

3.1.3 Yield Control by Area

72. Yield control by area has expanded since first introduced to the Mora Forests in 1948. It is a rational form of management, permits exploitation to be concentrated with consequent improvement in the effectiveness of field staff and allows the concentration of road construction and logging facilities. Marking for felling is done on a silvicultural basis and since the coupe is exploited over a limited period conditions for the regeneration of a new crop are improved. In most areas no follow-up silvicultural tending is attempted.

3.1.4 Intensive Natural Regeneration

73. Exploitation followed by weeding, thinning, etc., as described under 2.4 "Management of Forests placed under Systems of Natural Regeneration" has now almost ceased. Areas suitable for such work have proved highly suitable for the growing of *P. caribaea* and since the average increment of these plantations is about $15 \text{ m}^3/\text{ha/annum}$ compared with $5 \text{ m}^3/\text{ha/annum}$ under a regenerated mixed hardwood crop it is obviously more effective to switch to pine plantations. In addition charcoal-burners who were an integral part of the system no longer operate and in some cases large areas have been used for quarrying and pine has proved a satisfactory species for post-quarrying rehabilitation.

74. One feature which appears controversial is the present plans for the future management of that part of Arena Reserve which will remain as mixed hardwood forest (as opposed to those parts planted in pine after quarrying operations ceased). The treatment of the Reserve was completed in 1963 under the system described in 2.4 above where it is shown that the system had evolved from what is generally known as the Tropical Shelterwood System to a polycyclic system under which fast-growing hardwoods would be harvested on a cycle of 30 years and the traditional slower growing species on a cycle of 60 years. In a plan drawn up for the period 1971 to 1980 it is stated that management will be by a selection system, i.e. under a completely different concept of management from that under which the Reserve was regenerated previously. This raises question of whether or not a

selection system can open up the canopy sufficiently to promote the vigorous type of regeneration which has proved successful in the past. In addition, no studies have been made to assess the felling and extraction damage which such a system causes and in this respect it is worth noting that in Uganda it was found that from 5% to 15% of the stand per tree felled had to be considered too severely damaged for an adequate survival of the larger poles and adolescents. This question of polycyclic fellings as opposed to the selection system is one which is not of paramount importance to Trinidad at the moment since only relatively small areas are involved but in the future it is a question which will have to be clarified in relation to the new crop arising under the block system of exploitation. Now would be the time to lay down research plots to obtain the answers which will be required.

3.1.5 Regeneration by Planting

75. During the period 1980-1982, 830 ha of teak and 778 ha of pine were planted. Nursery and planting techniques are well established and such difficulties as exist are confined to management after the establishment phase. In the case of teak, thinnings have fallen behind schedule and Tanteak (the Government-owned plant for sawing teak) is pressing for a higher proportion of large dimension thinnings than would be silviculturally prudent. The thinning of teak has been dealt with in studies for provisional yield tables (data from which are shown at Figures 1 to 3) and in these studies it is suggested that when the crop reaches 7.5 m height the stocking should be reduced to 960/ha, that when the basal area has built up to 18.6 m²/ha a second thinning should reduce this to 11.3 m²/ha and that when the basal area has again built up to 20.1 m²/ha a thinning should reduce this to 14 m²/ha.

(NOTE: The data quoted are direct conversions from quarter girth feet/acre to m²/ha).

76. What has become clear since the yield table study was made is the success which has attended the planting of pine on the flat tops where teak grows indifferently. If this were widely adopted the thinning of teak plantations would be simplified in that teak growth would be much more even, the Class III sites being almost exclusively planted with pine.

77. Reference has already been made to the effect of genetically controlled early flowering on the form of teak. Since seed stands in compartments of 25 years and over have been chosen for form and vigour it follows that most early flowering trees have been eliminated during thinnings and the seed now available is of much higher quality than that formerly available. Wider initial spacing is therefore a topic which should be investigated once more using on this occasion only seed from designated seed stands.

78. The yield table study referred to above discusses options concerning the age at which clear-felling should take place and points out that if Class I teak is felled at age 50 years the stumpage value would amount to \$ 2 500 per ha. If this sum were invested at 4% it would appreciate to \$ 8 100 by the year 80 whereas if the crop were allowed to grow on to age 80 the stumpage value would increase to only \$ 3 370 per ha. Alternatively the stumpage value could be raised by 230% to break-even. Thus, in the management of teak vis-à-vis rotation age three courses are open. These are:

- a) Clear-fell at age 50 years
- b) Allow to grow on and accept a poor return
- c) Allow to grow on and increase stumpage fees substantially.

Urgent decisions are now required on these matters.

79. Regeneration by planting pine is now averaging some 260 ha/annum and during the past 10 to 15 years nursery and establishment techniques have changed little. As with teak plantations, post-establishment management is concerned principally with the timing and weight of thinnings to be applied and the economics of the operation. The cost of timber obtained from thinnings cannot apparently compete with the cost of imported pine but since the mean annual increment peaks at about the age of 25 years (Fig. 5), increment loss will soon become significant if older coupes are not thinned.

80. Studies made in 1969 in connection with the compilation of yield tables suggested that rotation age would most probably be 30-35 years and proposed that the simplest method of controlling a thinning programme for pine would be to allow the basal area to build up to about 31 m²/ha and to reduce this to about 22 m²/ha at a first thinning thereafter to permit the basal area to attain 33 m²/ha then to reduce this at a second (final) thinning to 26 m²/ha. This matter of thinning pine plantations is now urgent and decisions should not be long delayed.

81. In the case of watershed management, problems of organisation, techniques and species selection have been overcome and the rate of progress now depends upon the availability of funds. However, State and private lands form an intimate mix in many areas and effective management can only be attained if each catchment is treated as a whole and the solution would appear to be some form of Dedication Scheme for private owners which would commit them to acceptable management practices. Alternatively, private land within a catchment area could be acquired by Government in order to treat the area as a whole. Until such arrangements have been achieved planting can only be confined to larger, self-contained areas of State land.

82. As stated in section 2.8, final summaries of the National Inventory are about to be published and results indicate that the total standing volume of marketable species amounts to 12.01 million m³ of which 5.37 million m³ are in the North of Trinidad, 6.34 million m³ are in the South and 0.30 million m³ in Tobago. Of these volumes it is estimated that 65% of the volume in the North and 90% of the volume in the South are potentially accessible.

3.2 Socio-Economic Aspects of Management

83. Since the earliest deliberations on Forestry in Trinidad the policy, even if only tentatively formulated has been concerned with management of the forest estate to serve the local population. In addition, of course, the forests were not large enough or homogeneous enough to support an export trade of any consequence and forest development and management was therefore oriented entirely to the local market.

84. Although the population is now very much more mobile than formerly the main source of labour in forestry and related activities is still the rural towns and villages. Because of the part-time nature of much of the work connected with forestry it is difficult to place an exact figure on the employment created but estimates made in 1982 suggest:

| | |
|--|-------|
| Monthly paid forestry staff | 280 |
| Forestry workers (full time equivalent) | 1 100 |
| Felling, extraction, transport and saw-milling | 2 000 |
| Total | 3 380 |

85. As a result of new discoveries of oil and gas on land and in coastal waters living standards have improved rapidly and there is now a reluctance on the part of rural farmers to take up taungya gardens in the teak and pine plantations. In some ways this has improved efficiency since it has allowed the Forest Division to ensure that each compartment is under-brushed and felled early in the dry season thus ensuring a "hot" burn and thereby reducing weed growth in the first and second years. The absence of taungya farmers also eliminates the possibility of crops, particularly hill rice, being planted too close to the teak and so having the same stunting effect as excessive weed growth. On the negative side and in addition to higher costs of under-brushing and felling, the country loses some 700 ha of agricultural production each year and the rural population loses part-time but highly productive employment.

86. Expenditure on forestry greatly exceeds the revenue produced from the sale of forest produce and in 1977 the expenditure amounted to \$ 9.1 million and revenue to \$ 0.99 million. This large excess of expenditure over revenue is explained by the development and maintenance work (including road development and maintenance) being done in plantations and the management and protection of the whole forest estate, including critical water catchment areas outside plantation areas and in the provision of recreation areas for the population. Thus in 1977, 623 ha of commercial timber plantations were established and almost 15 000 ha of such plantations protected, treated and maintained as required and at a time when the yield from the plantations is still relatively small. On the credit side, however, saw-logs produced from the Natural Forest was sufficient to produce 60 106 m³ of sawn timber which, at the price in 1977 of imported lumber, produced a foreign currency of \$ 18.65 million.

4. FUTURE TRENDS IN FOREST MANAGEMENT

4.1 Timber Licensing System

87. From time to time there have been demands to grant concession licenses or exclusive rights to the harvesting of timber on specific areas. This system would seem to be more efficient than that of granting numerous licenses for small numbers of trees and if granted for say ten years would switch expensive roadmaking from the Forest Division to the concessionaire and permit the licensee to invest in harvesting and wood processing equipment. In addition, field staff of the Division could be deployed more effectively. However, the total volume exploited over the past few years has averaged about 90 000 m³ per annum and if concessions of any magnitude were granted, the effect on small-scale rural licensees would create hardship. If concessions were small enough to avoid this hardship the whole basis of improved efficiency would be undermined. In effect, the matter is a socio-political one and it is difficult to envisage any Government agreeing to a fundamental change in the licensing system which would have a detrimental effect on the rural communities.

88. Concessions within the teak plantations are quite different however since there has been no tradition established of licensees dealing in the relatively small dimension thinnings and therefore no difficulty created when marketing of round wood poles and sawn wood was commenced by the Forestry Division nor when sales were taken over by the Government-owned company, "Tanteak". In relation to pine plantations this has cleared the way for "Tanteak" to utilize the larger thinnings in a sawmill and, as the available volume increases, it would be relatively simple to install a pressure treatment cylinder so that a high durability produce can be marketed.

4.2 Land Use Planning

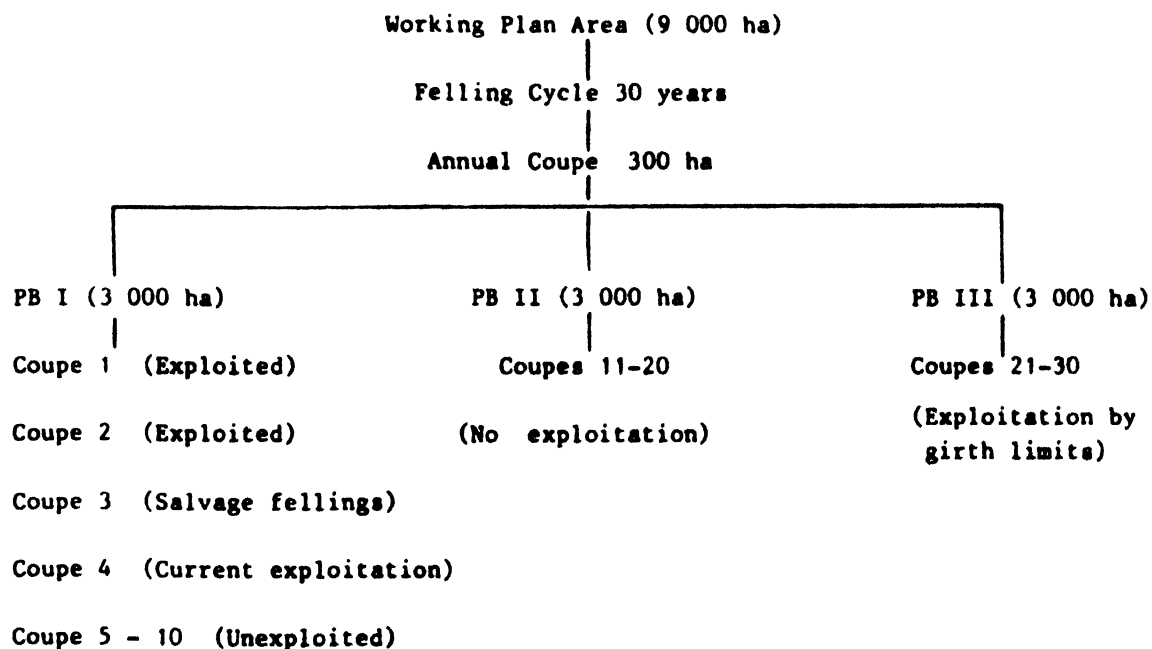
89. Where population density is as high as in Trinidad, integrated land use assumes great importance. The completion of the National Forest Inventory has greatly contributed to the refinement of land capability maps and the production of land use plans for major catchment areas. In practically all cases, however, squatting on State land will have to be tackled firmly. It would be socially and politically unacceptable to attempt to evict squatters who settled on the land outside forest reserves many years ago and demonstrations of more rational forms of land use combined with cash or other incentives are probably the only way in which this problem can be solved if current plans for watersheds are to achieve success.

4.3 Intensive Exploitation followed by Extensive Natural Regeneration

90. In the context of this assessment, intensive exploitation is taken to mean exploitation confined to a defined area during a stipulated period of time, e.g. an annual coupe or exploitation block in which trees to be harvested are marked for felling with a view to encouraging the regeneration of a new crop and in which girth limits might be reduced for individual trees or species if this is in the interests of the succeeding crop. Thus, a fast-growing secondary hardwood species whose normal girth limit is 150 cm might have the girth limit reduced to, say, 120 cm to induce adequate opening of the canopy and also to harvest trees which would be over-mature at the end of the following cycle of, say, 30 years. The object would be to harvest the maximum possible volume consistent with leaving an adequate number of pole-size trees to act as seed bearers, perching places for fruit-eating bats and birds and as the nucleus of a new crop. By extensive regeneration is meant the opening of the canopy to encourage regeneration but allowing this to come through without further cultural operations.

91. In areas where there is sufficient forest to operate this system on a cycle of, say, 30 years future working plans are likely to define the area to be exploited in the period of the plan (probably 10 years) and subdivide this area into ten annual coupes. Thus, the working plan will define the ten annual coupes forming the Periodic Block (PB) for that period and within the PB only two annual coupes will be open for exploitation, that of the current year and also the coupe of the previous year which will be kept open for salvage fellings and extraction. Two other PB's will be defined for the second and the third ten-year periods and the PB's will be designated PB I, PB II and PB III according to the sequence of exploitation. During the exploitation of PB I, PB II will be closed but depending upon the condition of the crop in PB III, selection felling controlled by girth limits may be permitted in order to utilise over-mature trees. The diagram below illustrates the scheme as applied to an area of 9 000 ha to be exploited on a 30-year cycle and which is exclusive of nature reserves, recreation sites, etc. In the diagram the current exploitation is located in PB I, coupe 4.

Illustration I



In practice it is unlikely that much exploitation will take place in PB III because of difficulty of accessibility to wheeled transport.

4.4 Management of Teak Plantations

92. The time now seems appropriate to implement changes in the management of the teak plantations especially in matters concerning selection of planting sites, initial spacing and the thinning regime. As stated in 2.5.1 above, teak grows poorly (almost exclusively Class III) when planted on and near the flat tops of undulating land but on such sites *P. caribaea* had produced excellent growth although existing areas are too small to state conclusively that such areas are uniformly of Class I pine quality. The inference is clear however, that in future, teak should be confined to the slopes and the tops reserved for pine. Both species are compatible since they are both resistant to fire and it would seem that the pine would probably remain healthy for a 50-year rotation of teak. Alternatively and depending upon market conditions the pine could be felled at 25 years to produce two rotations of pine during one rotation of teak.

93. In view of the improved genetic quality of teak seed, assessment of spacing trials may suggest a wider initial spacing and this would improve the popularity of taungya with small-scale farmers and, once the crops had been reaped would permit the establishment of a soil protecting and fire-retardant under-storey of indigenous species.

94. Earlier and heavier thinnings have been suggested in the study leading to provisional yield tables and in earlier work commenced in 1955 in which the object was to reduce the crop in thinnings at 5 and 10 years to 350/ha at the age of ten years, i.e. about four times the final crop stocking. This latter work also prescribed high pruning of half the 350/ha stocking at the age of ten years to a height of 5.5 m. In view of the continuing trend towards reconstituted wood faced with quality veneer for such items as furniture, panelling, etc. it seems logical that management should now give careful consideration to pruning in order to produce two potential veneer logs of knot-free timber from the age of 10 years onwards. Such pruning involves little cost since there are few persistent side branches in the lower 7 metres when the crowns have been given space for normal development and a good genetic strain of seed is used. In addition there is some evidence to support the view that it is close spacing which stimulates persistent adventitious branching as a method of compensating for the inability of the crown to expand because of a tight packing in the canopy.

95. The persistence of coppice growth after thinning produces competition for the remaining crop and inhibits the establishment of a mixed under-storey. More intensive management of the future is likely to eliminate such coppice by poisoning and this can be done safely using ammate.

4.5 Management of Pine Plantations

96. It is difficult to predict future trends in the management of the pine plantations since information concerning markets for intermediate yields is not available. If such markets do not develop, future plantations are likely to be established at the wider spacing of about 3.75 m x 3.75 m and first thinnings delayed until the trees cut could provide some saw timber. Apart from expanding the annual planting rate no other trend is apparent at this stage.

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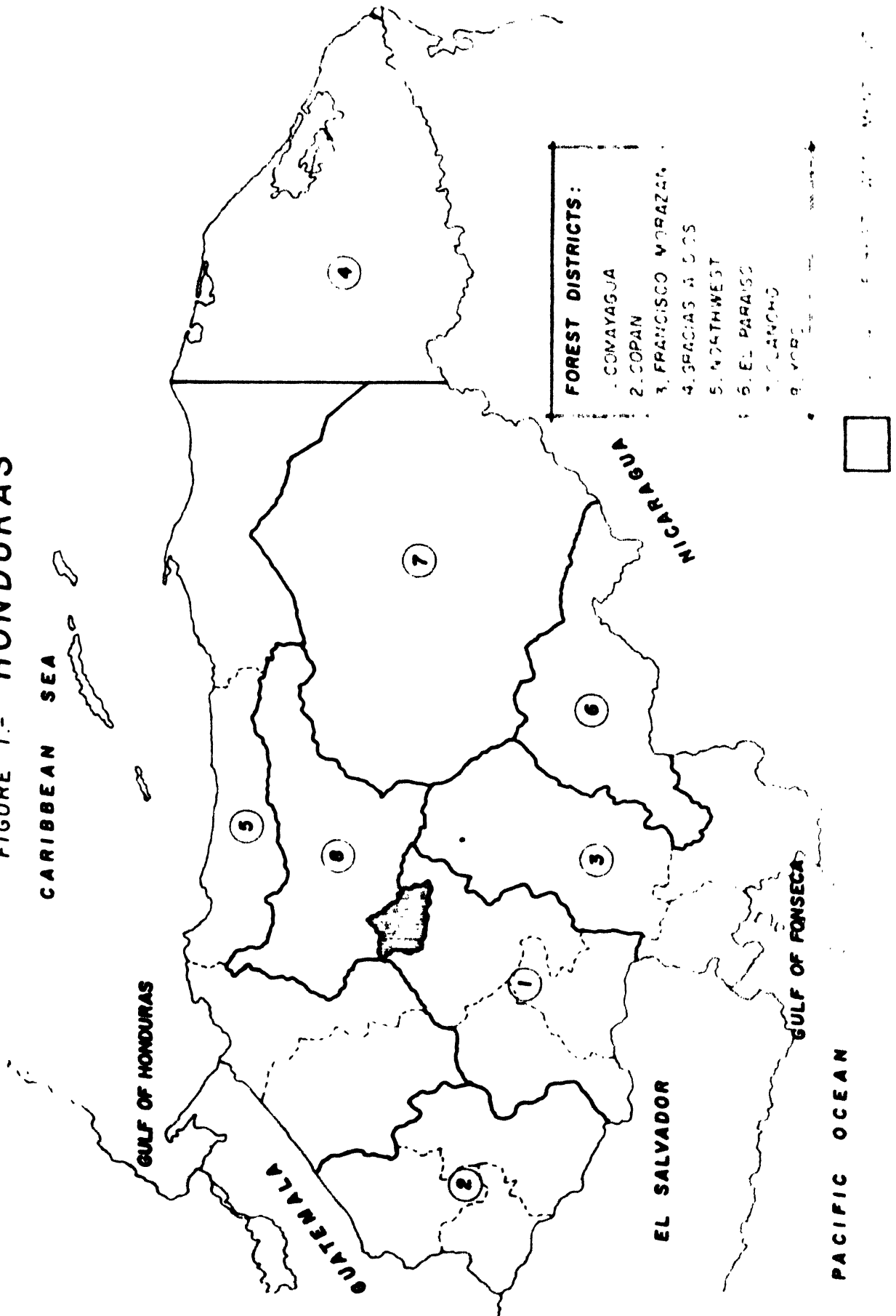
HONDURAS

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FIGURE 1.- HONDURAS



1. THE BACKGROUND

1.1 General Description of the Country

1. Honduras, with a population of 3.8 million and a per capita gross national product of US\$ 639.00 in 1980 is one of the poorest countries in the Western Hemisphere. During the 1950-1975 period the real gross domestic product increased at an average annual rate of 3.7% compared with the 2.7% annual rate of population growth. With a total land area of 112 100 km² the population density amounts to 34/km².

2. The economy is based predominantly on agriculture and forestry which together constitute about one-third of the gross domestic product, four-fifths of the exports and provide two-thirds of the employment. The extensive pine forests of the country are a most important resource but exploitation has been inefficient and highly selective and in consequence areas were depleted as access to the forests was developed.

3. The area of forest amounts to 64 000 km² of which 20 000 km² are broad-leaved, 24 000 km² are coniferous and 20 000 km² are mixed forest grass-land and forest fallow. The broad-leaved forests are generally located in areas with difficult access and because of low yields of commercial species and high harvesting costs, exploitation is limited. The pine forests on the other hand are widely exploited and the production of sawn pine lumber is the principal forest industry. Between the years 1979 and 1981 inclusive, the volume of hardwood exploited amounted to 105 000 m³ while the volume of pine harvested in the same period amounted to 3 128 million m³.

4. Although forest production methods have improved over the past eight years, inefficient harvesting and transport difficulties cause only 50% of the net commercial volume larger than 15 cm u.b. to reach the sawmill where wasteful production techniques results in only one-third of the harvested volume being produced as sawn lumber. Nevertheless, the forestry sector has been a traditional source of employment in the manufacturing area and the pine forests provide 97% of the raw material which generates this employment.

5. During the period 1969-1973 the average volume of pine harvested annually was 2.7 million m³ of which 59% was exported as logs and the remaining 1.32 million m³ provided the raw material for 140 local sawmills. Studies in 1973 revealed that only 12% of the harvested volume was transformed into sawn lumber and that this volume was much lower when expressed as a percentage of the standing volume. These studies also revealed that the price/m³ of harvested logs ranged from US\$ 0.05 to US\$ 0.09 and that exports were declared at only 47% of real value resulting in only 45% of real foreign exchange earnings accruing to Honduras. Since 1974, when forest administration was reorganized, the export of logs has been banned and the annual harvest reduced to around 1 million m³ per year.

1.2 Forest Administration

6. Conscious of the importance of the forest as a renewable resource, the need to rationalize its use and distribute the benefits derived throughout the Nation and the need to generate adequate foreign exchange earnings, the Honduran Corporation of Forestry Development (CONDEFOR) was formed in 1974 to manage the country's forests, export all primary wood products and promote social forestry development.

7. COHDEFOR is the semi-autonomous Honduras Forest Service whose Board of Directors is the ultimate authority. It is presided over by the President of Honduras and is composed of the following cabinet ministers: the Ministers of Treasury, Economics, Defence, Natural Resources and of the Planning Secretariat^{1/}. The General Manager acts as Secretary of the Board but has no voting rights. COHDEFOR comprises six support departments and essentially, four executive departments.

With the exception of the Forest Districts, the administration is entirely centralized and even the Districts depend on the central administration except for minor petty cash disbursements. Personnel management, selection, changes and/or dismissal are also centralized.

8. The General Manager of COHDEFOR is its sole legal representative and all timber sale contracts are signed and authorized by him. Timber sale contracts originate in the central office and are, supposedly, authorized by the District Chief after proper field inspection. However, some timber sale contracts are signed without a field inspection or technical opinion from the District. The exception to this is the annual contract which is based on a forest management plan as in the case of the Las Lajas Forest Management Unit (LLFMU). Contracts are based upon the annual Final Harvest Operating Plan which forms part of the timber sale contract. Inspections and authorizations are the authority and responsibility of the field personnel. Penalties or sanctions, however, are imposed on the authority of the General Manager and appeals are similarly dealt with.

1.3 The Comayagua Forest Development Programme

9. When COHDEFOR began to introduce management of the pine forests, in 1975, these were first divided up into large geographical units, each of which had sufficient water and adequate forest resources at the time, or potentially so, to make a future pulp mill feasible. On the basis of the value of these resources and existing infrastructure, priorities for development were drawn up for the 5 areas identified and first priority was given to the Central Highlands, the Comayagua area. This area covers some 11 000 km² of which two-thirds are forests which in the past had provided the major part of the country's production of pine lumber. It is transected by the highway that connects the Atlantic and the Pacific ports of the country, contains the site for one of the most promising hydro-electrical projects in Central America and is connected to the Atlantic port of Puerto Cortez by a railway line. Thus, access is good and plenty of water and energy would be available for future industries; good forest management would be a decisive factor for protecting the watershed and the artificial lake to be created.

10. During the first phase of the project (1982-1985), which was financed by the Inter-American Development Bank, four management units, covering a total area of 2 930 km² were put under intensive management. The first of these units, the Las Lajas Forest Management Unit (LLFMU) was, however, already established in 1976 and used as a pilot project to develop viable management methods for the rest of the country and train the Honduran foresters in the new management techniques.

11. This study will, in the following points, examine the Las Lajas Forest Management Unit as a case study of pine forest management in the tropics, the participation of forestry social groups in the benefits of resin production and processing and in the utilization of thinnings. The analysis has taken into consideration the investments required and the benefits expected during the first rotation of 45 years.

^{1/} Editor's note: In 1984, representatives from the Farmers Association and the Association of Woodindustries also became members of this board.

2. DESCRIPTION OF THE STUDY AREA

2.1 General Description

12. The Las Lajas Forest Management Unit (LLFMU) covers 77 598 ha and its name is derived from its largest population centre, Las Lajas. For administrative reasons, the Unit is divided into five sub-units each characterized by its topography, accessibility and the state of the resource base. These units and the areas of each are as follows:

| | |
|---------------------|-----------|
| Las Cruces sub-unit | 19 344 ha |
| Las Lajas Central | 16 998 ha |
| Valle Grande | 15 018 ha |
| Yure | 15 276 ha |
| Agua Blanca | 10 962 ha |

Each of these sub-units represents distinct geographical areas with well-defined topographical limits and relatively uniform forest resources.

Elevation within the unit varies from 130 m at the confluence of the Humuya and Sulaco Rivers to 1 733 m on the Cerro Negro.

13. For the purpose of describing accessibility, four classes of terrain have been defined, viz. easy, difficult, very difficult and inaccessible. Under the present system of harvesting it is estimated that about 25% of the area has been considered inaccessible and on 57% of the area harvesting falls into the "easy" class.

14. Geologically, about half of the area is of volcanic origin; about one quarter is of calcareous rocks of marine origin and the remainder of limestones and heterogeneous rocks including sandy and conglomerate quartz. Soils vary from poor shallow sands with a pH of about 5.0 through a range of pH values and depths to fertile alluvial soils suitable for intensive agriculture; the bulk of the soils, however, are rocky to stony, of medium to low fertility and not suitable for agriculture.

15. The climate in the LLFMU is characterized by a four-month dry season from January to April and a rainy season from May to December interrupted by a short dry period in July. Annual rainfall recorded over 9 years and at 6 meteorological stations averaged 2 100 mm/annum and the relative humidity varied from 65% in March to 85% in November. Average temperatures vary from about 22°C in January to about 27°C in May.

16. The area under pine forest in 1980 amounted to 39 059 ha and that under agriculture to 19 891 ha, an increase of 4% in the previous 3-year period. This increase took place at the expense of the hardwood forests (11 191 ha in 1980) but as accessibility to remaining forests of this type becomes more difficult, the pine forests will come under increasing pressure especially on the higher slopes, where soil fertility is adequate for agriculture. Of the pine forests, 48% are privately owned and 52% are in public ownership while the corresponding figures for the hardwood forests are 27% and 73%.

17. Studies in 1979 showed that the average ownership of land in the LLFMU is less than 2 ha per owner and that a significant proportion of families own no land; hence the pressure on forested land for agriculture. It has been realized that a need exists to incorporate the local population into forestry or agro-forestry activities and this has become one of the primary objectives of the Las Lajas Project (see also section 3.2.1).

2.2 Description of the Forest Resources

2.2.1 Forest Types

18. The inventory that supplied the data for the management of the LLF MU was carried out in 1977. Forest was defined as areas carrying a minimum of 10 trees larger than 3 m in height per ha or with a minimum crown coverage of 5%. Mixed stands were defined as "pine" when at least 20% of the crown coverage was pine.

19. Approximately two-thirds of the LLF MU's 78 000 ha are covered with forest out of which a quarter is mixed hardwoods and the rest pine. The broad-leaved forest grows on the steep slopes above 1 500 m a.s.l. and along rivers and streams; limited areas of mixed pine and oak stands exist in various parts of the unit. These forests have in general little commercial value but are preserved for protection purposes.

20. The pine forest covers some 39 000 ha and is composed of 3 species each occupying sites of different altitude although some mixing occurs. P. pseudostrobus Lindl. (now renamed as P. maximinoi) grows at higher elevations (approx. 1 100-1 700 m a.s.l.) and covers an area of some 4 000 ha (10% of the pine area). It is a fast-growing white pine that can reach large dimensions (up to 140 cm in diameter and 70 m in height). Since it often occupies relatively fertile soils, important areas of forest of this species have been cleared for coffee plantation. Natural regeneration after logging is often mixed with Liquidambar styraciflua L. and other broad-leaved species but the pine will eventually dominate. It rarely sprouts after cutting and young stands are less fire-resistant than those of the two other species. Mature stands are now mostly found in terrain with very difficult access.

21. P. oocarpa Schiede accounts for 63% of the total pine area and is therefore the most important species. It occurs from approximately 600 m a.s.l. and up to 1 100 m. This species seems not to reach the same size as P. pseudostrobus although trees with 90-100 cm diameter and 40 m height are not uncommon. With proper protection, good natural regeneration is obtained after logging, but repeated fires and heavy grazing take their toll although complete eradication seldom occurs; heavy grass can inhibit natural regeneration. Burning or cutting of plants or young trees up to 20 cm diameter results in profuse coppicing which makes this species very fire-resistant. Natural pruning is excellent.

22. P. caribaea Morelet grows at low elevations and is often difficult to distinguish from P. oocarpa in zones of overlapping; it covers 27% of the total pine area. Like P. oocarpa it is a yellow pine and the silvicultural characteristics are very similar; there are, however, some important differences: P. caribaea does not sprout after cutting or burning; heartrot is much more common in mature trees of this species and it is in general considered to be shorter lived in the LLF MU; it does not prune itself as well as the two other species and the form is in general inferior. Like the two other species, P. caribaea is light demanding and little regeneration occurs under dense crown cover.

23. The general impression of the mature pine forest today is one of open park-like stands with heavy grass and some scattered regeneration underneath. However, a closer examination reveals that all three pine species tend to form uniform even-aged stands and true multi-storied stands seldom occur. It was, therefore, quite easy to stratify the forest in young, medium and mature forest types. The density within each type is, of course, variable. Table 1 shows the distribution of forest types without the density sub-classes.

Table 1
Distribution of Pine Strata at end 1980^{1/}

| Pine Strata | ha | Area | % |
|--------------------------------|--------|------|-----|
| Forest under regeneration (PI) | 3 129 | | 8 |
| Regeneration (PII) | 8 459 | | 22 |
| Young Forest (PIII) | 4 083 | | 10 |
| Medium-aged Forest (PIV) | 508 | | 1 |
| Mature Forest (PV) | 22 799 | | 59 |
| Total | 38 978 | | 100 |

Source: CONDEFOR, 1981. Plan de Ordenación Forestal de la Unidad de Manejo de Las Lajas

As can be seen from this table a large part of the forest is mature while relatively little exists to immediately replace it. This management problem is dealt with later.

2.2.2 Volumes

24. The total, net, standing log volume was estimated at 2.1 million m³ ^{2/}. Ninety-two percent of this volume comes from old growth stands of commercial density (more than 25 m³/ha), and the remaining 8% comes from standing trees left after harvesting. Pulpable volume, that is wood from logs not usable for sawmilling and larger than 10 cm u.b. amounts to 0.7 million m³, bringing the total pine volume up to 2.8 million m³. The per hectare volumes are shown in Table 2.

Table 2
Net Standing Volume per hectare (m³ u.b.)

| Type of volume | Forest Types | | | Total Forest |
|----------------------------|-----------------|---------------|----------------------|--------------|
| | Mature PIV+V | Young PIII | Seed Trees PI+PII | |
| Saw-logs \geq 15 cm | 72 | 13 | 15 | 54 |
| Pulp wood \geq 7.5 cm | 20 | 38 | 3 | 17 |
| Total Volume \geq 7.5 cm | 92 | 51 | 18 | 71 |

^{1/} Excludes 535 ha that will eventually be flooded when the "El Cajon" hydro-electric project becomes operational

^{2/} 8% at p = 0.95; sound wood larger than 15 cm under bark

25. In order to facilitate planning and design of the wood industry and permit valuation of the forest, the inventory was designed to collect data for log size and quality distribution. For each strata a table was computed to show the number and volume of 5 m logs according to 10 cm size classes and 3 quality classes. It was discovered that the volume not presently utilized by the industry, that is logs of lower quality (III) and of diameters smaller than 25 cm small end, represented 31% of the total net standing by volume. When the losses due to felling and transport are added and the general malpractice of high grading is considered, less than 50% of the volumes shown in Table 2 actually reached the mill before the LLFMU was put under management.

26. All volumes were computed without bark and separate tables were elaborated to show bark volumes per strata and diameter classes. This would enable the industry to evaluate the total waste material available for fuel, viz. independent power production. On an average, a quarter to one-fifth of the total volume is bark.

2.2.3 Growth and mortality

27. In spite of the inaccuracy related to age determination of tropical pines, the gross increment was estimated for age and diameter classes and for strata averages. These results were combined with defect and mortality studies to give the net growth.

28. The results showed that mortality and growth seem to be of the same magnitude at the age of 54 (= age at breast height) in the present forest. Detailed defect studies show that cull rises sharply at about the same age and it was concluded that P. oocarpa should not be kept past the age of 60 when under management. (Not enough data were available to draw conclusions in respect to P. caribaea and P. pseudostrobus; however, indications are that P. caribaea suffered more from heartrot and seems to be shorter lived while P. pseudostrobus may be as long lived as P. oocarpa).

The strata averages for actual growth gave the results shown in Table 3.

Table 3
Net Increment of Trees larger than dbh 10 cm
(m³/ha/year u.b.)

| Forest Type | Net Increment |
|----------------------------|---------------|
| Regeneration w. seed trees | 0.7 |
| Young forest | 7.0 |
| Mature forest | 1.3 |
| Total forest | 1.0 |

2.2.4 Regeneration

29. All three pines regenerate naturally with little difficulty, provided the forest is protected from fire and excessive grazing. As can be seen from Table 4, all pine strata have an adequate number of plants per hectare; however, the distribution of the

plants is unsatisfactory as indicated by "% reg." which shows the percentage of 4 m² sample plots which have at least one living plant. Furthermore only the plants larger than 3 m in height are free from fire danger.

Table 4
Regeneration

| Forest Type | Number of plants per ha | | Regeneration % |
|---------------------------|-------------------------|------|-------------------|
| | <3 m | >3 m | |
| Forest under regeneration | 1 552 | 86 | 29 |
| Established regeneration | 3 474 | 407 | 52 |
| Young forest | n o t r e l e v a n t | | |
| Mature forest | 3 021 | 249 | 34 |

2.2.5 Site Class

30. The site class index in Honduras is based on height-age relations and the total range is covered in 6 classes. Both P. oocarpa and P. caribaea had average site class indexes that followed the "3" curve through all ages except the very young. Little variation was found between P. oocarpa sites while appreciable differences occurred between P. caribaea sites. Not enough information was available to classify P. pseudostrobus.

2.3 Description of the Human Resource

31. CONDEFOR with the assistance of National and International Agencies carried out a socio-economic survey of LLF MU in 1978 in which 79% of the 2 473 families living in the management unit were interviewed. The population in the management unit numbered 9 360, the average literacy rate was 49.6% and the average number of years of schooling amounted to 1.5 years. Some 84% of the families living in the unit own their own home although 76% of all families had no running water, conditions which account for the 67% incidence of gastro-intestinal disease in the young of the population. Health services of one form or another reach 88% of the population.

32. The main occupation of the area is subsistence farming (36%) followed by salaried labour (32%) coffee growing (12%), domestic service (5%) and forestry (1.6%). For those working for a salary, the average monthly remuneration was US\$ 52.16 and those not salaried earned an average of US\$ 27.35 per month. The average income amounted to US\$ 47.65 per month for the working population.

33. Some 56% of the energy required for lighting is based on pine wood (light wood) followed by kerosene and candles. In the case of cooking and heating, most families use fire-wood (mainly hardwood species) and based on national average consumption of fire-wood, the amount used annually in the LLF MU is about 12 500 m³.

34. A significant proportion of agricultural land is held by small farmers whose holding is less than 3 ha. Thus, two-thirds of land under annual crops and one-third of land under permanent crops are of this category, a situation made worse by the fact that half

of the population has no land for permanent crops and one-third has no land for annual crops. These facts together with the lack of applied technology and absence of production incentives contribute to the low productivity and income of the local population.

35. The situation relating to land occupancy and land ownership is complicated by lack of cadastral survey and by existing legislation. In a survey carried out by COHDEFOR in 1979 it was revealed that although only 24% of the LLFMU is registered as privately owned, 61% is fenced and considered private by the local population. The law empowers COHDEFOR to manage all forest land independently of ownership so that a land owner is subject to the overriding decisions of COHDEFOR in the use and management of his forests. The ownership of the timber, however, is vested in the landowner and up to 40% of any stumpage fees charged by COHDEFOR may be returned to the established forest owner as payment for his timber.

3. FOREST POLICY AND MANAGEMENT IN THE LIFMU AREA

3.1 The Policy Implications of Legal Objective

36. Existing legislation and especially the law creating CONDEFOR laid down as an objective for the Corporation, the responsibility for the optimum use of the forest resources of the country including their protection, conservation and improvement. It further established the need to protect the forests from fire, to ensure adequate use of forest lands and to institute watershed management. The responsibility therefore lies with CONDEFOR to formulate within the law a Statement of Policy and although this has not yet been accomplished, a number of objectives relating to technical forestry have been identified and these have been incorporated in a management plan drawn up for the LIFMU area.

37. The law relating to CONDEFOR also stated that "the Corporation will organize the Forestry Social System integrated by Honduran 'campesinos' (rural population) associated in working groups, cooperatives or other associative forms to care for and protect the forest and promote its regeneration, preventing fires, excessive grazing, illegal harvesting and shifting cultivation. It will also determine the fashion in which the 'campesinos' will participate in the benefits derived from the exploitation of the forest". The law further states that in forest zones where agricultural land use is available, CONDEFOR will cooperate with the National Agrarian Institute (INA) to determine their use for crops and cattle grazing and INA will allow permanent settlements to organized forestry groups and will promote social services and credit facilities to such groups for development purposes. In areas presently denuded but destined for forestry, the law stipulates that CONDEFOR will develop agro-silvicultural projects in close association with organized groups of forestry 'campesinos' and in forested areas such groups will be given preference in harvesting activities including resin-tapping.

38. In 1980 an agreement was signed between CONDEFOR and INA defining forest and agricultural land and establishing cooperation between both institutes in respect of the Comayagua Forest Development Project area. Since land use surveys have not yet commenced no impact has been made on land use in the area.

39. Due to the existence, prior to the formation of CONDEFOR, of groups of resin tappers, the Forestry Social System has been directed primarily towards the promotion and assistance of such groups but in some cases their existence prior to the introduction of planned management has proved an impediment to progress.

40. Before leaving the policy implications of the objectives as stated in the law, it is useful to summarize the findings of an FAO technical cooperation mission (TCP/HON/8906) in 1979 relating to an evaluation of the Forestry Social System. These conclusions included the following: 1/

- a) Forestry organised groups do not have a clearly defined role in the primary objectives of CONDEFOR and as such these groups can become a hindrance to the achievement of such objectives;
- b) There is a need to define a cooperative model adapted to the Honduran situation including the aspirations of CONDEFOR and the Forestry Social System;

1/ In 1983, after the writing of this study, a special project on Social Forestry was initiated to formulate and demonstrate various options for people's participation in forest management

- c) The real and potential capacity of the forest to support its population needs to be established. CONDEFOR's law, in effect, proposes to incorporate man into forest development. This has a certain economic-productive limit since socio-economic problems cannot be solved by the forestry sector alone;
- d) There is an urgent need for participatory planning of the Forestry Social System groups. This lack of planning has been responsible for an average rate of desertion of 20% from these groups. Most groups are in a pre-cooperative stage; they do not own forest land or timber and lack of security has been a major cause of desertion or failure.

3.2 Forest Management in the LLFMU

3.2.1 Objectives of Management

41. The long-term objectives governing the management of the forests of the LLFMU have been identified as follows:

- a) The attainment of sustained yield.
The forests will be managed in such a way that maximum benefits will be attained in perpetuity.
- b) Harvesting continuity.
The harvesting of the present mature and over-mature forests will be so regulated that during the next 10-year period the annual cut will remain more or less constant in order to stabilize raw material supplies to industry.
- c) Other Forest Products.
The demand for fire-wood and other domestic timber will be satisfied, as far as possible, from non-commercial timber or from stands specifically designated for the purpose.
- d) Provision of grazing.
Grazing in forest areas will be so controlled that it does not prevent the attainment of other objectives of management.
- e) In the interests of soil and water conservation and the protection of El Cajon Lake against sedimentation critical areas will be given protection as a priority over other uses.^{1/}

42. Bearing in mind the prescriptions contained in the law (paragraph 26), consideration had to be given to how best to incorporate social objectives in the management of the area. The density of grazing by cattle, goats, horses, etc. within the management unit is one animal unit per 2.5 ha of forest and it has been shown that mechanical damage from such grazing in regeneration areas amounts to 30% of the crop planted. In addition, 70% of the fires occurring in the unit are attributable to fires arising from slash and burn agriculture and the renewal of pasture. In spite of the importance of these factors careful consideration has led to the belief that for the time being resin-tapping is the only significant area in which the participation of the local population can be integrated into forest management and even then the gross total income from tapping would amount to only US\$ 85 000 per annum compared with US\$ 1.78 million from the production of lumber.

1/ Lake created by the hydro-electric project "El Cajon"

43. The problems of proper land use in relation to the destructive methods of agriculture as practiced over much of the area, land occupation and validity of tenure, grazing, fire protection and the directives of the law are such that rational objectives and means of attaining these objectives will have to be evolved for social forestry within the management unit. Until this is done studies to identify the means of attaining the objectives of social forestry must continue.

3.2.2 Division of the Area

44. Each of the sub-units listed in paragraph 9 was divided into compartments on the basis of the uniformity of the potential use of the land, the composition and potential use of the crop (pine forest, hardwood forest, protective or productive forests, etc.), the area required to constitute a logging unit handled by one landing and accessibility of the whole compartment to tractors as well as accessibility to the existing road network from the compartment. Wherever possible natural features such as rivers, gorges, etc. have been chosen as the boundaries of the compartments but where these do not exist, straight lines have been used. The size of the compartment varies but is not greater than the area covered by one year harvest and not smaller than 25 ha. Experience has shown that the average area covered by a compartment is about 100 ha. Compartments are numbered in sequence starting from the South-West corner of each sub-unit and the number is prefixed by the first letter of the name of the sub-unit, thus Y - 1 is compartment 1 of the Yure sub-unit. In this manner 1 120 compartments were identified on the aerial photographs and transferred to a base map of the unit.

3.2.3 Description and Measurement of the Crop

45. For the purpose of describing the growing stock, five strata were identified and where necessary, these strata subdivided to record density of regeneration, quality of growth, etc. The five strata were as follows:

| | |
|-----------|--|
| Type PI | Recently harvested forest now under regeneration with or without adequate number of seed trees |
| Type PII | Regeneration with or without seed trees |
| Type PIII | Stands with diameter at breast height (dbh) between 10 and 25 cm |
| Type PIV | Stands with dbh between 25 and 35 cm |
| Type PV | Stands with dbh greater than 35 cm. |

46. This stratification of the forest was in itself an important management measure. Each strata represents a "cutting" or "treatment class" requiring specific inputs and producing logs of known dimensions: PI may require afforestation; PII may need completion of the natural regeneration and require removal of seed trees; PI + PII requires complete protection against fires and grazing; PIII may need thinning (density class 3) and controlled burning, only poles and small size logs will be produced; PIV-3 should be thinned and PV is ready for resination and final harvest; PIII, PIV and PV may be grazed.

47. Although the general inventory gives average volumes and log yields per ha of the different strata, each compartment is inventoried prior to harvest, thinning or afforestation and precise prescriptions drawn up. The management gives general prescriptions in terms of magnitude (area, volumes), methods to be employed and priority compartments; but the annual operation plan is based on the precise information derived from the compartment prescriptions.

48. Descriptions of the crop are entered on Compartment Description Registers which in addition contain the usual information in relation to area, soils, slope, aspect, access, percentage defect, etc. and such details are entered where possible on the base map referred to in paragraph 44.

3.2.4 Rotation of the Crop

49. From the examination of 471 sample trees of *Pinus oocarpa* and *Pinus caribaea* (which are similar in growth and increment characteristics in the Las Lajas area) it would appear that maximum yield is obtained at 47 years of age but since age was measured at breast height the age of 50 years would be a closer estimate for the period from reforestation to harvesting. These observations were made in natural and unmanaged stands but in managed stands which are subjected to such cultural operations as thinning, it seems reasonable to expect maximum yield at an earlier age.

50. The present mature and over-mature stands have very low net increment if any at all (see Table 3, paragraph 28) and more than 40% of the volume is affected by defect (paragraph 28). It is logical, therefore, that the mature and over-mature crop should be harvested at a rate faster than the straight forward application of the principles of sustained yield might suggest and a subjective compromise must therefore be applied. In this case a rotation of 45 years has been decided upon and a theoretical area control of 1/45 of the forest area should therefore be harvested each year. Flexibility must, however, be maintained to accommodate such variables as stand maturity (or over-maturity), accessibility, density of stocking, etc.

3.2.5 The Annual Allowable Cut

51. The simplest approach to calculating the quantity to be cut each year is that mentioned in paragraph 50, i.e. "area control" in which the total area is divided by the rotation period in order to determine the "annual coupe". The Management Plan 1981-85 for the LLFMU shows the area and distribution of the strata (paragraph 37) within each sub-unit in Table 5.

Table 5
Pine Strata Areas Available for Management (ha)

| Sub-units | Strata | | | | | Total |
|---------------|--------------|--------------|--------------|------------|---------------|---------------|
| | PI | PII | PIII | PIV | PV | |
| Lajas Central | 362 | 3 954 | 1 770 | 305 | 3 535 | 9 926 |
| Agua Blanca | 806 | 1 208 | 569 | 59 | 1 299 | 3 941 |
| Las Cruces | 942 | 1 647 | 757 | 18 | 8 666 | 12 030 |
| Valle Grande | 460 | 716 | 494 | 81 | 3 505 | 5 256 |
| Yure | 559 | 934 | 493 | 45 | 5 794 | 7 825 |
| Total | 3 129 | 8 459 | 4 083 | 508 | 22 799 | 38 978 |

Based on an area of 38 978 ha and a rotation of 45 years the theoretical annual coupe is therefore $38\,978/45 = 866$ ha.

52. Since the forests of the area contain mature and over-mature stands which should be harvested as early as possible (paragraph 50) a conversion period can be calculated during which these stands will be harvested and converted to dynamic young stands. The period during which this conversion will take place is obtained by dividing the area of the mature stands (22 799 ha: Table 1) by the area of the annual coupe (866 ha: paragraph 51).

$$\frac{\text{Mature Pine Forest Area}}{\text{Annual Coupe}} = \frac{22\,799}{866} = 26.3 \text{ years}$$

In addition to the annual coupe, a proportion of seed trees standing over younger but established compartments would also be harvested each year.

53. Inventory studies have shown that the total volume of the PV stratum amounts to 1 248 782 m³ measured to a 15 cm top diameter (u.b.). The annual cut on the basis of converting this stratum over a 26.3 year period would therefore be:

$$\frac{\text{Total PV Volume}}{\text{Conversion Period}} = \frac{1\,248\,782}{26.3} = 47\,482 \text{ m}^3/\text{year}$$

If the top diameter for utilisation is increased to 25 cm the available volume falls to 37 036 m³/year. These volumes represent the volumes placed at mill site after the deduction of 8% for losses in logging and transport and 5% loss due to inaccessibility.

54. Estimates have also been made of the volumes which will become available in future years as intensive management is applied. Such yield would arise principally from thin-nings and from the harvesting of seed trees in younger stands. These estimates will be subject to change at each revision of the working plan and as data is accumulated from actual results; the estimates are likely to progressively improve in accuracy.

3.2.6 Harvesting Plan for the Period 1981-1985

55. The selection of the areas to be harvested during the current period of the management plan has been influenced by the accessibility of compartments to the existing road system and by the proximity of the two established circular sawmills. For these reasons the sub-units Yure and Las Cruces have been selected. As can be seen from Table 6, the total annual harvest area for the next five-year period is 18% higher than the theoretical annual coupe and the volumes to be harvested some 15% lower than the volumes theoretically available. These differences are due partly to selection felling in some of the areas between 1975 and 1980, that is, after the aerial photographs used for this plan were taken and partly to a lower stand volume than the average volume calculated in these sub-units.

Table 6
Summary of Harvesting Plan 1981-1985

| Area | 1981 | 1982 | 1983 | 1984 | 1985 | Total | Average |
|----------------------|--------|--------|--------|--------|--------|---------|---------|
| <u>Yure sub-unit</u> | | | | | | | |
| Area (ha) | 394 | 377 | 479 | 560 | 335 | 2 145 | 429 |
| Vol. m ³ | | | | | | | |
| ≥15 cm | 20 488 | 19 800 | 19 820 | 19 970 | 19 940 | 100 018 | 20 004 |
| <u>Las Cruces</u> | | | | | | | |
| Area (ha) | 697 | 784 | 621 | 282 | 594 | 1 978 | 596 |
| Vol. m ³ | | | | | | | |
| >15 cm | 20 570 | 21 140 | 20 358 | 19 060 | 20 650 | 101 770 | 20 354 |
| <u>Total</u> | | | | | | | |
| Area (ha) | 1 091 | 1 161 | 1 110 | 843 | 929 | 5 123 | 1 025 |
| Vol. m ³ | | | | | | | |
| >15 cm | 41 058 | 40 940 | 40 170 | 39 030 | 40 590 | 201 788 | 40 358 |

The volumes estimated for 1981 were derived from compartment records and those for the four other years are based upon the results from the general inventory.

3.2.7 Other Prescriptions for the Period 1980-1985

56. The management plan prescribes, by compartments, other works to be carried out during the period of the plan. These works include harvesting of seed trees, planting, direct sowing, road maintenance and prescribed burning together with the appropriate areas, volumes, number of plants, etc. involved. A summary of such other works for the period of the Plan 1981-1985, is given below.

57. Harvesting of Seed Trees and Thinnings. This operation is carried out in PIII and PIV strata; the area to be thinned annually will average 276 ha and it is estimated that these operations will produce an average annual yield of 3 907 m³ of logs with a top diameter of 15 cm or larger.

58. Regeneration. Regeneration of specified areas is carried out by means of natural regeneration, direct seeding or by planting. A minimum of 10 parent trees per ha are left on all areas harvested during the period 1981-1985 even if the prescription is to replant. This procedure is undertaken to continue forest cover and thereby discourage encroachment. Where natural regeneration is prescribed, the only operation undertaken is that of fire protection. Direct seeding is confined to areas with rock surfaces or

with very difficult access on which natural regeneration is inadequate. The average number of sowing spots is 2 000/ha with about four seeds per spot. Seeding operations take place in May and only in the Yure sub-unit, during the 5-year period. Planting is undertaken in other areas deficient in natural regeneration. The normal spacing adopted is 2.2 m x 2.2 m in areas subject to some grazing or 2.5 m x 2.5 m in areas not subject to grazing. In areas where some natural regeneration exists the spacing is 3 m x 3 m, if the existing regeneration is less than 3 m high, or 5 m x 5 m where it exceeds 3 m in height.

59. Nursery. Seedlings are raised in the nursery at Valle Bonito camp-site in 4.7 x 12 cm bags with multiple perforations in the bottom to induce root pruning by exposure of the roots to the air. A mix of 3:1 soil and sand to which 2 kg/m³ of superphosphate fertilizer has been added is used to fill the bags. The bags are placed on screen tables 80 cm high, and direct sown with 2 seeds per bag. Periodic fertilization with NPK and control measures against pests and fungi are undertaken and the object is to produce seedlings of about 20 cm height in 22 weeks. Sowing is continued at weekly intervals to produce suitable plants throughout the planting season of June to September.

60. Reforestation. The areas reforested by either direct sowing or by planting are specified by sub-unit and compartment. A summary of these prescriptions is shown in Table 7.

Table 7

Annual Areas of Reforestation and Requirements of Seeds and Plants

| Year | Plantations (ha) | Plant require- ments x 1 000 | Direct Seeding (ha) | Seed require- ments for di- rect sowing (kg) |
|---------|---------------------|------------------------------------|---------------------------|--|
| 1981 | 456 | 506 | | |
| 1982 | 1 106 | 997 | 237 | 72 |
| 1983 | 1 088 | 979 | 249 | 75 |
| 1984 | 928 | 834 | 192 | 58 |
| 1985 | 645 | 583 | 159 | 47 |
| Total | 4 223 | | 837 | |
| Average | 845 | | 167 | |

61. Fire Protection. The type of forest fire occurring in the management unit has been mentioned in section 2.2. Studies have revealed that ideally, for fire prevention and control, a road density of 1 km/400 ha would be required. Such favourable circumstances are unlikely to be attained in the foreseeable future but the following prescriptions have been made as preventive measures:

- a) Identification of critical areas and the concentration of road maintenance and construction crews in each area at times of high fire risk.
- b) Controlled burning before replanting of clear-felled area.
- c) Controlled burning after pre-commercial thinning.
- d) Controlled burning one year prior to resin-tapping.

Rules are also laid down for the location and design of fire-breaks; a series of maps in connection with the suppression and recording of fires has been prepared and a fire danger rating system is in use. Prescriptions for the 1981-1985 period include the construction of two additional observation towers, the controlled burning of 8 112 ha, the construction of 110 km of fire-breaks and the maintenance of a further 230 km.

62. Road Infrastructure. Specifications are laid down for primary and secondary roads and for skid trails. These roads are built by logging contractors but the design and lay-out is the responsibility of the LLFMU personnel. COHDEFOR maintains the 64 km of main roads in the area.

63. Resination. Since it was originally thought that resination should be carried out by a cooperative of local inhabitants, a special plan was drawn up that considered the resination of mature stands 4 years prior harvesting. Financial help would have been given to the cooperative to acquire tools, vehicles, materials and a portable camp. All the technical and administrative prescriptions and supervision would be the responsibility of the COHDEFOR personnel in the management unit, who would also market the resin and do the necessary accounting.

64. Although the plan was ready for implementation and the economics of the scheme looked very promising, it has until today remained an academic exercise. The reason has to be sought in the worry that once established, the cooperatives would not follow the plan of tapping all trees 4 years ahead of the harvest, which would require periodic movement of the work camp, but rather insist on a continuous, low yield tapping of the stands assigned to them, thus blocking them against harvest and, in effect, upsetting the whole management plan. Although this fear is somewhat justified, other approaches to the problem could have been tried, but were not for the reason that no regular communication exists between COHDEFOR and the population living in or close to the forest, and during the years, antagonism rather than trust has characterized the relation between the two parties. This criticism is, however, more directed towards the institution COHDEFOR rather than the management schemes of the LLFMU. A serious try was made to integrate the local population but so far the plan has been held up by the central administration.

3.2.8 Management Controls

65. The Final Cut. Logs are marked and numbered according to the compartment in which they were cut and the volume is measured at mill site. Volumes are then entered in the Harvest Compartment Registers. Field supervision is carried out and contractors may not move into another compartment until the LLFMU staff are satisfied that all contractual terms have been met. Compartment inventories and prescriptions formulated one year before harvesting commences, form, where appropriate, part of the harvesting contract. The sale of whole compartments on a standing volume basis has been considered but not yet implemented.

66. Regeneration. Assessments of the previous year's regeneration areas are made each April and the necessary prescriptions made to replant or reseed as required.

67. Thinnings. Areas prescribed for thinning are assessed one year in advance of the work commencing and detailed prescriptions formulated.

68. Other Works Register. (Activity Registers) The Other Works Register is the repository for all miscellaneous works undertaken in the management plan area and these are entered annually.

69. Periodic Planning. This corresponds to the Annual Programmes common to most management plans and is undertaken within the general planning scheme of the five-year plan to meet such modifications as may become necessary and, in the last year of the five-year period, to serve as an overall evaluation and general adjustment of the goals to be attained in the second five-year period.

70. Costs. A cost accounting system has been designed for the management unit but not yet implemented.

3.2.9 Manpower requirements

71. The management plan includes an evaluation of the seasonal and yearly manpower requirements to operate the management unit. The results are shown in Table 8.

Table 8

Manpower Requirements in LLFMU (1981)

| Post | Forester (B.S.) | Forest Ranger | Surveyor | Accountant | Foremen | Skilled labourers | Management support <u>1/</u> | Labourers <u>2/</u> |
|------------------------|--------------------|------------------|----------|------------|---------|----------------------|------------------------------------|---------------------|
| Administration | 1 or | 1 | | 1 | | | 9 | |
| Management | | 2 | | | 4 | | 1 | 6 |
| Silviculture <u>3/</u> | | 1 | | | 2-4 | 4-6 | 1/2 | 13-39 |
| Logging/ roads | | 1 | 1 | | | | 1/2 | 2 |
| Protection | | 1 | | | 4 | | 9 | 32 |
| Nursery | | | | | 1 | | | 9-54 |
| Total | (1) | 6 | 1 | 1 | 11-13 | 4-6 | 20 | 62-133 |

1/ Drivers, radio operator, secretary, cook, etc.

2/ Shows seasonal variation; the lowest number indicates permanent labourers

3/ All thinning operations are done directly by the unit

72. Data concerning manpower requirements for specific operations are still being compiled but estimates indicate that in direct seeding activity 2 man days/ha are required whereas in plantations it is 3 man days/ha. The labour requirements in thinning vary from 18-22 man days per hectare depending upon the type of thinning to be done (commercial or pre-commercial), the stand density and the site factors.

73. The labour involved in the production of one million seedlings amounts to 4 145 man days and if an average planting density of 1 800/ha is assumed the labour cost in man days is 7.5/ha for planting material.

3.2.10 Investment Requirements and Analysis of the Las Lajas Forest Management Programme

74. The Working Plan for the Management Unit has compiled a series of financial tables including investment requirements, capital and cost requirements for a 45-year rotation, volumes to be made available by the LLFMU Forest Management Programme (for 45 years), discounted cash flow and distribution of the present net worth of the management programme, etc. They are projections based mostly on what it is hoped that management will achieve during a 45-year rotation and since actual results are available for only two/three years this summary will only include a few key figures from the analysis.

75. Investments. The average annual investment between 1981 and 1985 will be as shown below (it should be noted that a permanent camp has already been established).

| | <u>US\$ (1981)</u> |
|----------------|--------------------|
| Thinning | 880 |
| Reforestation | 930 |
| Protection | 6 270 |
| Nursery | 4 680 |
| Camp-site | 3 830 |
| Transportation | 31 220 |
| Total | 47 810 |

or US\$ 0.91 per ha of forest; this is equivalent to 0.26 man day of unskilled labour (1981: US\$ 3.46 including social benefits).

76. Operating Costs. The corresponding operating costs are estimated as follows:

| | <u>US\$</u> | <u>%</u> |
|-------------------------------|----------------|--------------|
| Logging | 5 190 | 4.0 |
| Thinning | 16 340 | 12.5 |
| Reforestation | 12 510 | 9.6 |
| Protection | 31 010 | 23.6 |
| Nursery | 11 830 | 9.0 |
| Infrastructure | 20 968 | 16.0 |
| Administration and management | 26 560 | 20.3 |
| Camp-site | 6 490 | 5.0 |
| Total | 130 898 | 100.0 |

or US\$ 2.48 per ha of forest; this is equivalent to 0.72 man day unskilled labour.

77. Gross revenue. At present, only sawtimber logs with a diameter (u.b.) larger than 25 cm are used by the sawmills. If the average cut for the period 1981-85 were to be 34 000 m³ and the price per m³ maintained at US\$ 4, the gross revenue would be US\$ 136 000 or US\$ 2.57 per hectare of forest (productive + improductive). If the most recent estimates of the residual value are used (US\$ 21/m³) the gross revenue would amount to US\$ 714 000 or US\$ 13.52/ha/year.

4. POTENTIAL DEVELOPMENT AND CONSTRAINTS

4.1 Potential Development

78. The Las Lajas model has been accepted as a model management scheme for the pine forests of Honduras and as such will have significant influence on a number of other areas now being brought under management. The first area to fall under the influence of the management system of Las Lajas is that of the Olancho Forest District which has 5 500 km² of pine forest destined to produce the raw material for a major forest industry development project. The development will include two sawmills with a combined input of 724 000 m³ and a projected pulp and paper mill. The forest management plan and its implementation follows the Las Lajas model; implementation is in the preliminary phase and is expected to become operational by 1983.

79. A second unit to base management on the Las Lajas model is that of Macuelizo which includes some 350 km² of pine forest. This unit is already operational.

80. The most far reaching influence of the Las Lajas management scheme has been on the Comayagua Forestry Development Programme of which Las Lajas is a part (see paragraph 9). Presently it has been introduced in three management units and by 1985 it will be implemented in 4 units covering a total of 2 930 km² of pine forest. If all these programmes are implemented, Las Lajas will have become the model for 50% of the pine forests of Honduras and certainly for over 85% of the production forests of the country.

81. It is, however, important to point out that the Las Lajas model has laid little or no emphasis on multiple use and too little on the social forestry aspects (paragraph 42), features which this analysis has shown to be of great importance. This is a factor which must be kept in mind at the planning stage of future work and at the revision of existing management plans.

82. Another factor of great significance in the application of the Las Lajas model to other pine forest areas is that of timing. Recent studies indicate that if the sawmills continue to utilise only top grades of logs of 30 cm top diameter or more and harvest only those areas with a commercial volume of 30 m³/ha or more, the average life of the productive pine forests of Honduras (except the Olancho Forest Reserve) will be no more than 15-18 years on the basis of the most favourable assumptions. In addition, taking into account the high selectivity of harvesting and the over-mature nature of many forest areas, the net presently commercial increment of the pine forests in the country is less than 0.6% per annum. There seems no alternative, therefore, to the imposition of a much more rational system of harvesting and utilisation followed by effective regeneration and management techniques if the environmental, social and economic consequences of the present destructive mining of the forest resource are to be avoided.

4.2 Constraints to Development

83. The direction and form of future forest development in Honduras have been discussed in the foregoing chapters particularly with reference to the form of management proposed for the Las Lajas unit. Constraints to such development have emerged and these may be classified as institutional (legal, forest policy, decision-making and personnel management) economic and industrial constraints.

4.2.1 Legal Constraints

84. The Agrarian Reform Law states that forest land shall be managed in accordance with the existing forest legislation while the law relating to COHDEFOR states that once forest land has been classified as such, COHDEFOR shall manage it and will promote agro-silvicultural programmes jointly with INA. Although some land-use criteria were agreed upon by both institutions in 1980 as a result of the Comayagua Forestry Development Programme, there is no soil survey information available to make the implementation of such an agreement possible and it may be many years yet before the necessary data become available to permit the application of optimum land use.

85. Although COHDEFOR's Law allows for the management of forest, independent of ownership, no legal provisions exist to ensure the survival of natural or artificial regeneration on privately owned land following harvesting of an existing timber crop. This deficiency severely limits sustained forest management and has already caused a reduction in the area of pine forest. It is also of immediate importance since much of the 1981-85 reforestation programme in Las Lajas is scheduled to be undertaken on privately owned forest land and if owners deny the right to reforest such land as they may, the future of forest management in IIFMU is in jeopardy.

4.2.2 Forest Policy

86. Forest legislation in Honduras which includes a forest resource law and that which provided the legal base for the creation of COHDEFOR is conceptually advanced, not least in the provision of social development as a responsibility of the forest administration. In addition, the autonomy that financial strength gives to COHDEFOR provides the organization with a solid base and the capability to finance forest management programmes for rural development. However, continuity in the management of the institution has been fragmented with five general managers in eight years resulting in changes in policy to conform with the changing political atmospheres of the country. Since forestry and the continuous supply of forest products to industry are long-term ventures, this discontinuity of policy has adversely affected both forest management and the development of forest industries.

87. On the other hand, the policy dictated by COHDEFOR has been one-sided and has not taken proper account of the necessary participation of the private sector (forest industry, logging contractors, private land owners, etc.) nor of the rural sector (municipal forests, 'campesinos' associations, cooperatives and occupants of forest land). If the development of forestry and the forest industries are to succeed, close linkages must be forged and coordination established between the institutional and industrial bases whose continued existence is dependent upon a common resource base, i.e. the forest estate. In this respect, a major constraint to forest development, and consequently forest management, has been the one-sided and paternalistic attitude to the formulation of policy and the imposition of decisions within the forestry administration. The consequences have been confrontation rather than cooperation among the component institutions and bodies, all of which are separately interested in, and could benefit from, development of the forest resource and the industries dependent upon it^{1/}.

^{1/} See also foot-note to paragraph 7

88. A further constraint to the development of forest policy is the infrequency with which COHDEFOR's Board of Directors meets. Although the Board is presided over by the President of Honduras and members are Cabinet Ministers thus ensuring authoritative policy-making and strong political support for the forestry administration, the very composition of the Board is such that meetings cannot be convened with a desirable frequency and a year may elapse between one meeting and the next. Thus a more active mechanism is required to provide COHDEFOR with greater policy-making support and control.

4.2.3 The Decision-making Process

89. It has already been pointed out that the application of sanctions, the resolution of appeals and the signature of timber contracts are the exclusive prerogative of the General Manager of COHDEFOR. In the LLFMU, as well as in other FMU, it has frequently happened that the central administration has been disregarding the management plan and approved increase in harvest volumes or increase in industrial capacity. Obviously, the communication at different levels in the forest administration is not satisfactory and decentralisation of authority would make for greater efficiency in management.

4.2.4 Personnel

90. The development and implementation of the Las Lajas forest management model, as well as its potential expansion in other areas of Honduras, have involved the training of a significant number of personnel from semi-skilled and skilled labourers to the lower and middle management levels. In spite of these efforts and because of changes in COHDEFOR's top management, the substitution of trained staff by untrained staff, even at low and middle management level, has had to be undertaken to the detriment of forest management programmes from the planning to the implementation stages.

4.2.5 Economic and Industrial Constraints

91. The more intensive the utilisation of the forest resource the greater the return on investments in forest management are likely to be. Even at this early stage of development, a reduction in the minimum acceptable top diameter limit (at present 30 cm) would provide increased economic returns not to mention the benefits which would accrue from the utilisation of smaller diameter timber for pulp wood. However, so long as the lumber or other wood-using industries have no incentive to improve utilisation standards, progress will be slow and it is therefore incumbent upon COHDEFOR to develop appropriate incentives and financial and technical assistance programmes to achieve a greater intensity of utilisation and hence help ensure a longer conversion period of the forest resource from unmanaged to higher yielding managed forests.

92. Although the prospect of a pulp wood scheme is highly attractive, Honduras is not in a position to finance such an industrial development in Las Lajas from its own resources. Indeed a pulp and paper project for the Olancho Forest District has been under consideration for 20 years but investment costs have proved an insurmountable difficulty to date. At present, the stumpage is arbitrarily fixed and actually only represents a fraction of the full residual value of the timber. This is a severe obstacle to investment in forest management and the development of social forestry groups and, in effect, means that the corporation is subsidising the sawmilling industry. COHDEFOR has recognized this situation and has recently decided to reduce significantly investment in forest management especially since other sectors of the economy are not in a position or are unwilling to fund this subsidy. Some mechanism to integrate the entire forestry sector in this endeavour is therefore urgently needed.

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93. The alternative of outside financing for forest management programmes also has limitations. Mention has already been made of the IDB financing of the Comayagua Forest Development Programme of which Las Lajas is a part. However, the loan contract stipulates that management activities funded by the project must be confined to nationally owned lands even although the private lands form an integral part of the forests which should be managed as an entity.

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